May 1951

Defenders of Freedom

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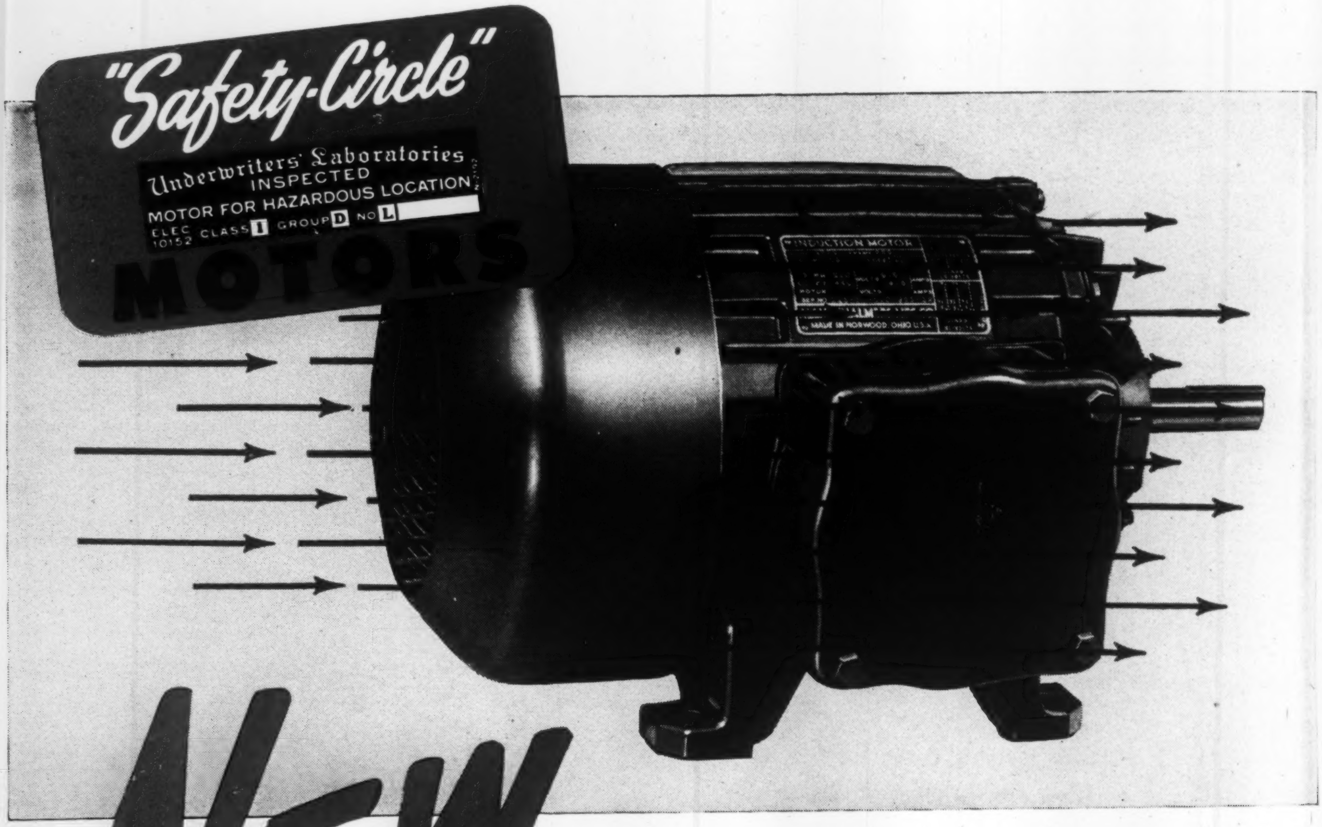
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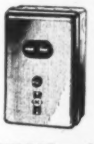

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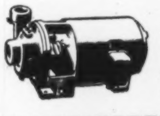

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MACHINE DESIGN

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

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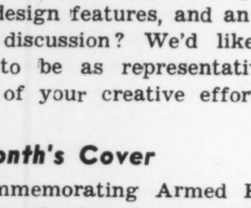
Over the Board

Contemporary Design

Under this somewhat formidable head we present each month a pictorial feature illustrating typical new machines. Our purpose is to show you the sort of work your contemporaries in the machine design field are doing and, perhaps stimulate your thinking along lines a little different from your own specialty. Machines to be featured are selected from several standpoints such as attractive appearance, clever engineering design, and availability of information concerning them that would appeal to engineers. Has your latest design been pictured here? If not, how about sending us a glossy photograph, a cross-sectional drawing showing noteworthy design features, and an engineering discussion? We'd like this feature to be as representative as possible of your creative efforts.

This Month's Cover

In commemorating Armed Forces Day, May 19, the "Mighty Mo" has been selected as a proved engineering masterpiece to symbolize the slogan, "Defenders of Freedom." Shown are crewmen on quad 40-mm gun mounts standing by as the 16-inch forward turret fires a salvo at Communist installations at Kansong. Observance of the day includes a tribute to the Armed Forces as a part of the spiritual power of America now being mobilized and a renewal of faith in our country's ideals of peace and freedom, to the preservation of which this power is dedicated.



A New "Fellow"

Author of the current series of engineering data sheets on stress concentration factors (Page 159 this issue) is R. E. Peterson, manager of the mechanics department at Westinghouse research laboratories. This month "Pete" makes the headlines by becoming a Fellow of the American Society of Mechanical Engineers. Elevation to the grade of fellow comes only after long and distinguished service to the mechanical engineering profession.

Thanks

Your response to the verification cards which our circulation department sends out each year has been highly gratifying. In 1950 the return cards showed 93.8 per cent of the recipients of MACHINE DESIGN wanted to continue receiving the magazine, 3.2 per cent didn't want it, and only 3 per cent failed to reply. This return reflects a degree of interest which we find most encouraging—thanks for the lift.

This seems like a good place to remind you that we welcome your comments and suggestions at any time. As we have pointed out before, it is physically impossible for us to meet every one of you personally. We'd like to know why you like MACHINE DESIGN (or why you don't), so let's have your orchids or brickbats, whichever seem appropriate.

SBME Again

A couple of months ago we told you a little about the Society of Business Magazine Editors whose emblem appears at the foot of Page 3. Like other professions, the editorial world has its standards of professional conduct and here is how the SBME expresses them in its *Code of ethics for business magazine editors:*

I believe in and seek to practice:

Editorial Accuracy. With reader interest as the paramount responsibility I shall report objectively facts as I find them . . . seeking always to lend strongest support to the business, profession or industry I serve.

Editorial Judgment. Because the publication of injudicious, unfair or untrue statements undermine honest business magazine editorial practice, I shall judge wisely the words I print.

Editorial Competitiveness. While I respect the rights of other editors and honor copyright privileges, I believe in full freedom of the press and in editorial initiative.

Editorial Service. My publication serves a fundamental purpose in stimulating the flow of goods and services . . . therefore I direct my effort to building a fount of data for my readers. To them I devote the sum of my knowledge and the accumulated experience of the publication I edit.

Editorial Leadership. I shall endeavor to stimulate my readers to constructive thought and action on vital issues affecting them so that my magazine may bring enlightened leadership in its field.

Coming Next Month

In view of the urgent need for maintaining well-staffed engineering departments in all key machine building industries, a special 32-page section on evaluating engineers is being readied for the June issue of MACHINE DESIGN. This timely article by Randolph W. Chaffee is a searching analysis into the basic problems of evaluating engineering work and of recognizing and rewarding real talent and effort. Engineers and engineering executives will find it well worth reading and studying. As usual extra copies will be available for the asking.

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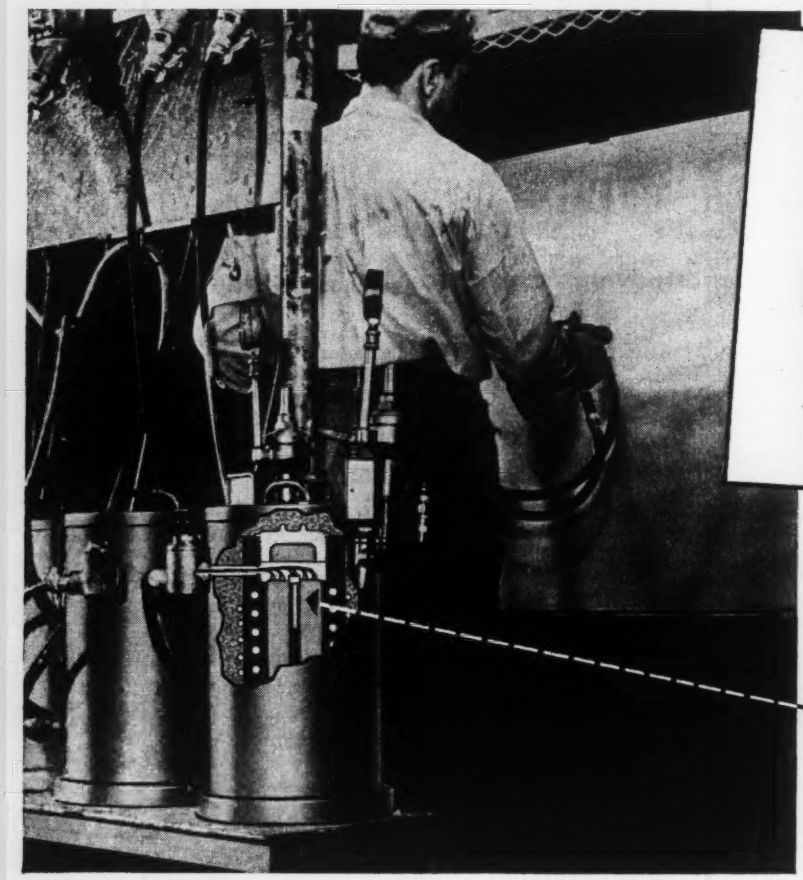
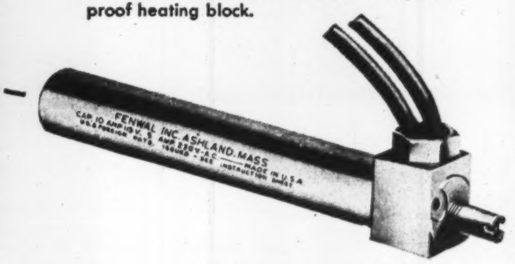


Multi-Purpose Thermostat helps solve heat-control problem in Bede Paint Heater

BEDE PAINT HEATERS, used to speed up paint spraying and save material by heating both paint and air, rely on Fenwal Block Head THERMOSWITCH Unit installed in explosion-proof heating block.



When Bede Products, Inc. originally designed the Bede Paint Heater it faced a primary problem: safety.

Underwriters' Laboratories, Inc. cautioned against the danger of electrical heating in paint spraying areas. So a metal block with pipes for paint and air was made explosion-proof by a special surface cover and fittings. The temperature control unit, which had to be compact, economical and accurate, could then be located in the block, flanked by heating elements.

LOW-COST SOLUTION

A Fenwal THERMOSWITCH Unit — 8/10 of an inch in diameter — met all specifications: low cost, precise performance, compact size, high current-carrying capacity. By this, it enables Bede Paint Heaters to lower the cost of paint spraying throughout industry.

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Many types of control problems can be solved by easy-to-install, easy-to-maintain Fenwal THERMOSWITCH thermostats. Their activating control element is the single-metal shell that expands or contracts *instantaneously* with temperature changes, making or breaking the totally enclosed electrical contacts. Through this unique principle, THERMOSWITCH Units effectively control *many* variables where heat is a factor.

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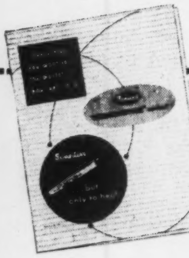

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☐ Alarm (over-temperature, under-temperature)
☐ Vapor Control
☐ Timing (thermal)
☐ Radiant Heat Control
☐ Pressure Control (by controlling vapor temperature)

OTHER (Please fill in your special requirements) ....
....
....

MAY, 1951

MACHINE DESIGN
A PENTON PUBLICATION

No Skeletons in the Closet

THE HUMAN tendency to place ourselves and others on one or the other side of some imaginary fence can hamper thinking. For instance the designer of machinery becomes, after hours, a user of machines such as automobiles, household appliances, and lawn mowers. But if he can project his experience and thinking as a user into his work as a designer, his effectiveness on the job will be greatly increased.

What machinery user is not well aware of the many faults and deficiencies of other peoples' designs? The repair man who fixed that dishwasher the other day was quite outspoken in his criticism of what "the engineers" had done or failed to do in creating a weak design and making it difficult for him to get at the offending parts for servicing.

The designer who is not hearing such complaints about his own designs need not be too complacement. Chances are they exist but are somehow being sidetracked or hushed up. If so it is high time to do something about it. As a valuable source of ideas for design improvement, customer complaints merit the most careful consideration.

To put these ideas to work requires two steps—establishment of close working liaison between engineering, sales and service departments to insure prompt transmission of complaints, and systematic analysis of these complaints. As Philip Emrich told the SAE in a recent paper, complaints must be analyzed for kind of failure, point of failure, conditions under which failure occurred, and the reason for failure. Additionally, frequency of failure out of balance with sales can quickly show up basic weaknesses which prompt action can correct on the rest of the production run.

It is generally agreed that no amount of pretesting can eliminate every single "bug" in a new design. Performance of the production model in service therefore should be watched just as critically as the test models. The rational view regards service failures, and the complaints which they generate, not as skeletons in the closet but as profitable aids to improved design.

Colin Carmichael

EDITOR

By T. C. Lloyd
Chief Engineer
Robbins & Meyers, Inc.
Springfield, Ohio

Specifying Standard

DESIGN economy and practical advantage through use of standard parts are well-known to most designers. However, full employment of such units in design depends to a great extent upon a simple, systematized method for selection and specification. Such parts are largely purchased components running into thousands of items, from small to large quantities in each. They are the familiar screws, bolts, washers, rivets, etc., commonly used in the design of machines. This article is intended to describe a drawing system used to specify standard parts.

The system outlined has replaced one of 50 years standing but a brief review of this previous setup helps define the problem. All standard parts required a drawing with a drawing number. The drawing number was used to identify the item on the material list as released for production (rather than a written description) and for purchasing, material control, and stock. As the system grew over a long period, the drawings were never planned, so that some might show an individual washer, for instance. Others might tabulate six or eight items, each identified by a group number. Grouping was chronological rather than in a logical sequence of sizes.

Old System Unwieldly

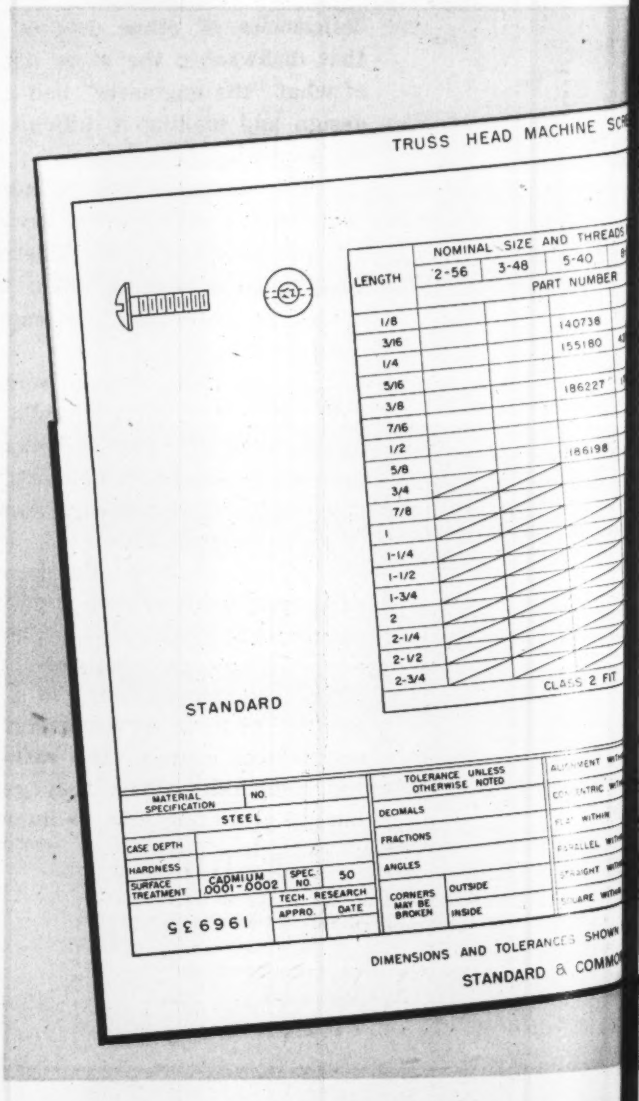
To locate an item in the drawing file required an index of standard parts. Indexing was usually periodic, so that in a fairly large and scattered engineering department there was excellent opportunity for duplication of drawings between indexing periods. Some of the drawings in active use (or which might be picked up for service) dated back as far as 1910. In the meantime, national standards had changed many dimensions. Such a drawing sent out to suppliers might bring up the question as to whether a standard rivet, for instance, would be suitable or whether a "special" was to be supplied as indicated through obsolete dimensioning.

Such was the existing condition with little to recommend it except that it was firmly entrenched in usage. The labor involved in introducing a more logical system and changing over material lists, records, and many other details had always discouraged change.

This situation is not uncommon in engineering organizations with many years of continuous operation behind them. The solution to this problem and the resultant development of a new system can be of general interest to many engineering offices. Consideration of the factors involved permit the specification of general principles for approaching such a problem. Two factors are involved:

1. A system of making and tabulating standards parts drawings
2. A method of administering the completed system with follow-up.

METHODS OF SPECIFYING STANDARD PARTS: It be-



TRUSS HEAD MACHINE SC

LENGTH	NOMINAL SIZE AND THREADS		
	2-56	3-48	5-40
	PART NUMBER		
1/8			140738
3/16			155180
1/4			
5/16			186227
3/8			
7/16			
1/2			186198
5/8			
3/4			
7/8			
1			
1-1/4			
1-1/2			
1-3/4			
2			
2-1/4			
2-1/2			
2-3/4			

CLASS 2 FIT

STANDARD

MATERIAL SPECIFICATION	NO.		
STEEL			
CASE DEPTH			
HARDNESS			
SURFACE TREATMENT	CADMIUM .0001-.0002	SPEC. NO.	50
196935		TECH. RESEARCH	
		APPRO.	DATE

TOLERANCE UNLESS OTHERWISE NOTED
DECIMALS
FRACTIONS
ANGLES
CORNERS MAY BE BROKEN: OUTSIDE
INSIDE

DIMENSIONS AND TOLERANCES SHOWN
STANDARD & COMMO

Parts

Adequate planning and care are necessary to assure "standard parts" systems which really achieve the considerable cost advantage offered by their use

came apparent from an examination of standard parts drawings available from other organizations that systems vary greatly. *Fig.* 1 shows two drawings used by one large organization for specifying truss head machine screws. The initial drawing gives only the type, size, length, and material, identified by a part number. Hence, a ¼-inch, 8-32 screw was part number 42,003 while the same screw ⅜-inch long was part number 179,254. The drawing number, showing these parts and many more, is still different, being 196,935. No dimensions are given. These are shown on the supplementary drawing as indicated. Obviously a different series of drawings were needed for each type of screw (round-head, fillister head, etc.) and for each material or finish.

In contrast to this system is the one used by the U. S. Army Air Corps, shown in *Fig.* 2. Here one basic drawing gives both the dimensions and the identification. That is, the drawing number 501 applies to all fillister head machine screws, drilled or plain, with fine threads, of a range of materials covered by group letter. Thus, 501B6-8 is such a screw,

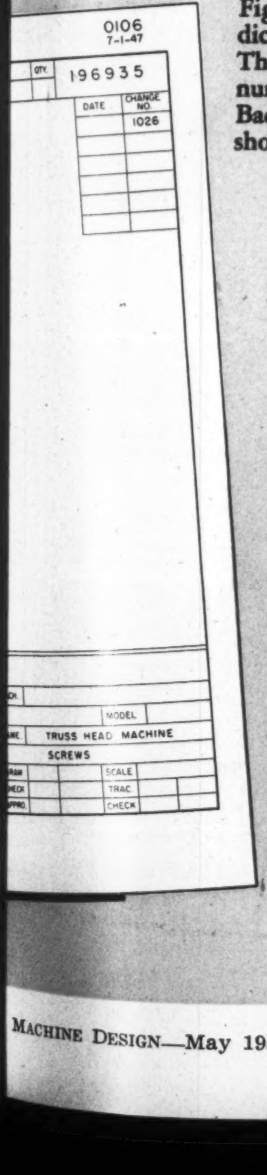
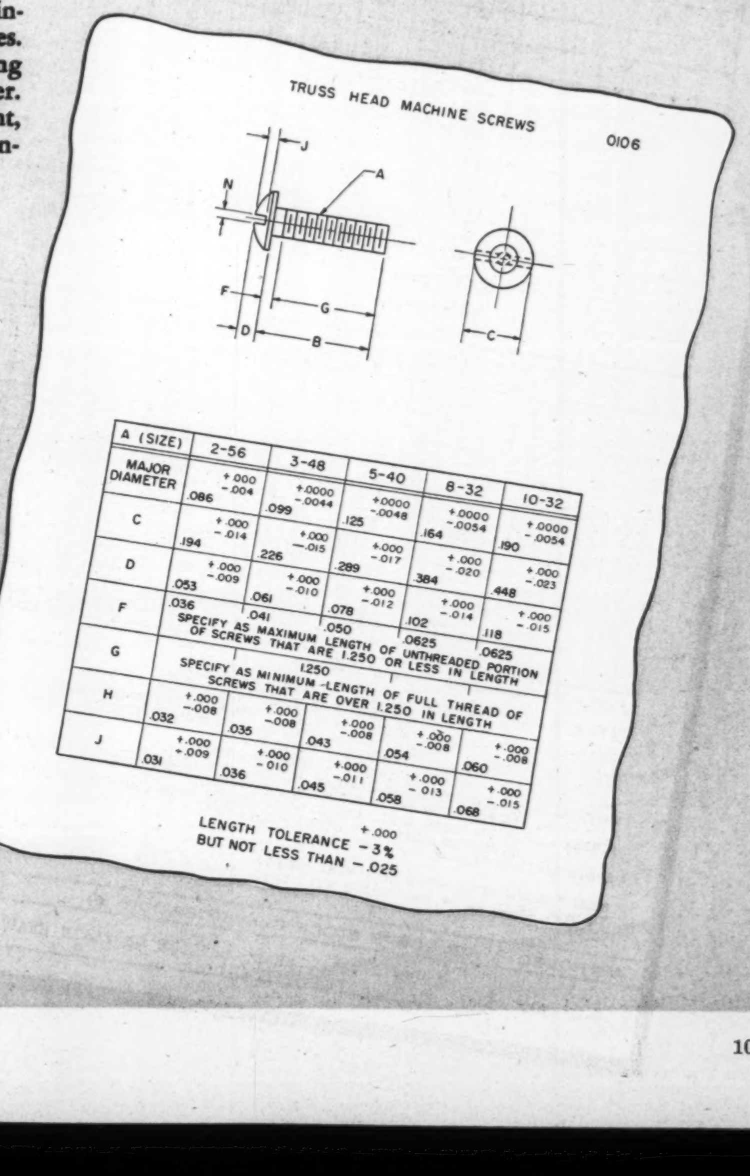


Fig. 1—One method of indicating various screw sizes. This system uses a drawing number and a part number. Back of the sheet, right, shows drawing with dimensions



A (SIZE)	2-56	3-48	5-40	8-32	10-32
MAJOR DIAMETER	.086 +.000 -.004	.099 +.0000 -.0044	.125 +.0000 -.0048	.164 +.0000 -.0054	.190 +.0000 -.0054
C	.194 +.000 -.014	.226 +.000 -.015	.289 +.000 -.017	.384 +.000 -.020	.448 +.000 -.023
D	.053 +.000 -.009	.061 +.000 -.010	.078 +.000 -.012	.102 +.000 -.014	.118 +.000 -.015
F	.036	.041	.050	.0625	.0625
G	SPECIFY AS MAXIMUM LENGTH OF UNTHREADED PORTION OF SCREWS THAT ARE 1.250 OR LESS IN LENGTH 1.250 SPECIFY AS MINIMUM -LENGTH OF FULL THREAD OF SCREWS THAT ARE OVER 1.250 IN LENGTH				
H	.032 +.000 -.008	.035 +.000 -.008	.043 +.000 -.008	.054 +.000 -.008	.060 +.000 -.008
J	.031 +.000 +.009	.036 +.000 -.010	.045 +.000 -.011	.058 +.000 -.013	.068 +.000 -.015

LENGTH TOLERANCE +.000 −3%
BUT NOT LESS THAN −.025

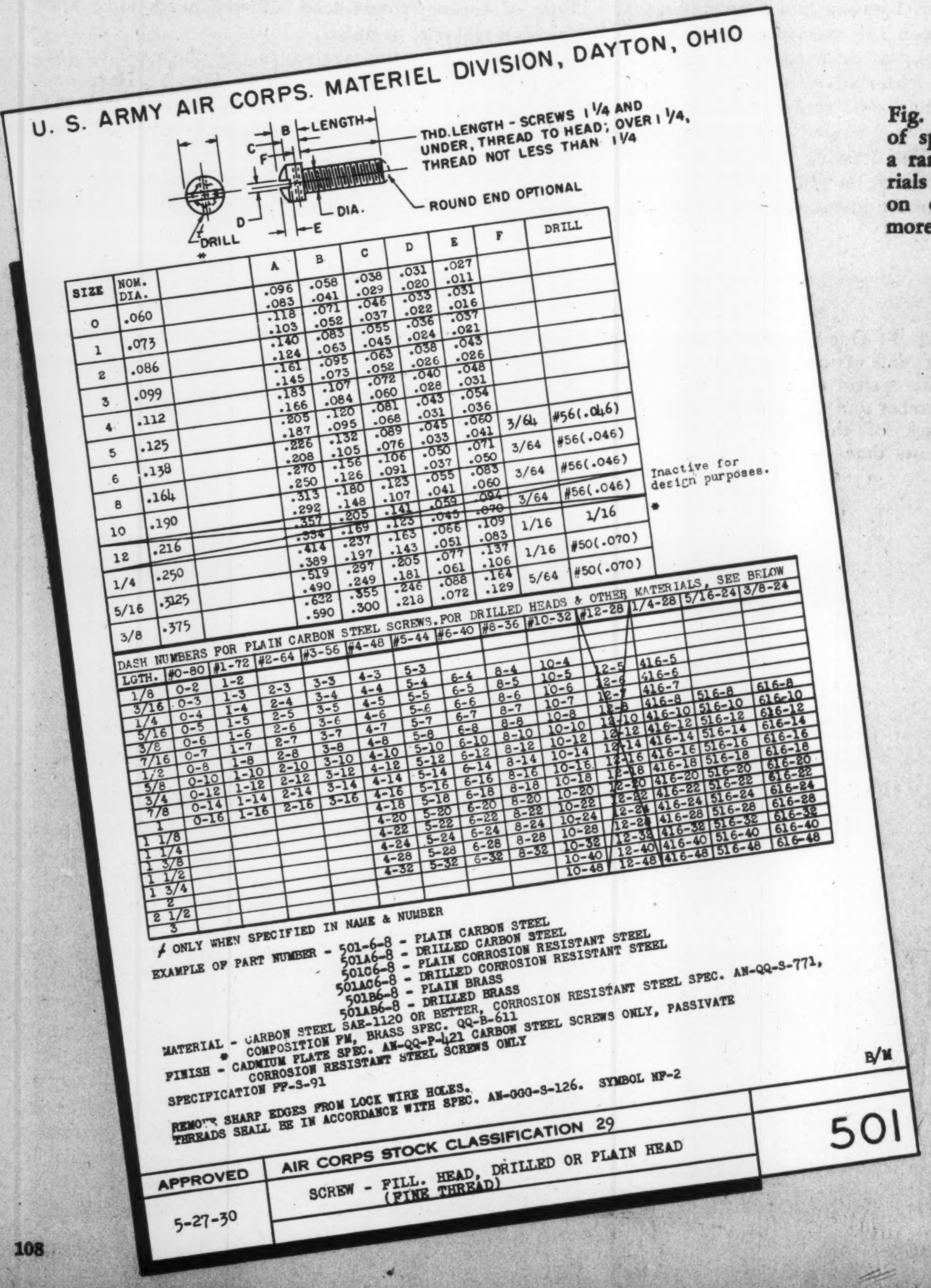
a 6-40, ½-inch long, made of brass. The first *number* of the *group* covers the diameter (6) while the second dash number (−8) gives the length in sixteenths of an inch. All screws 1 inch long then become −16, etc.

While only these two systems are shown here, others based on still different methods were examined. It was decided that while they each had advantages, they also possessed disadvantages when applied to the problem at hand. Accordingly a fresh start was made from which the general precepts outlined in the following paragraphs were brought forth.

First, the drawing number and part number should be fundamentally the same. Thus, a part identifie basically as F10 should appear on a drawing havin the same symbols. Regardless of whether such drawing is filed separately, or bound, this simplifie the problem of filing and location.

The drawing number should differ widely from an series of numbers now in use. Considering that th new system was to replace the old, any material lis or stock record was then obviously corrected or no by casual examination of the drawing number. Thi was especially useful during the transition period immediately after the new system was introduced.

What was covered basically by one drawing and



U. S. ARMY AIR CORPS. MATERIEL DIVISION, DAYTON, OHIO

B
LENGTH
C
F
D
E
DIA.
DRILL
*

THD. LENGTH - SCREWS 1 1/4 AND UNDER, THREAD TO HEAD; OVER 1 1/4, THREAD NOT LESS THAN 1 1/4

ROUND END OPTIONAL

SIZE	NOM. DIA.		A	B	C	D	E	F	DRILL
0	.060		.096 .083	.058 .041	.038 .029	.031 .020	.027 .011		
1	.073		.118 .103	.071 .052	.046 .037	.033 .022	.031 .016		
2	.086		.140 .124	.083 .063	.055 .045	.036 .024	.037 .021		
3	.099		.161 .145	.095 .073	.063 .052	.038 .026	.043 .026		
4	.112		.183 .166	.107 .084	.072 .060	.040 .028	.048 .031	3/64	#56(.046)
5	.125		.205 .187	.120 .095	.081 .068	.043 .031	.054 .036	3/64	#56(.046)
6	.138		.226 .208	.132 .105	.089 .076	.045 .033	.060 .041	3/64	#56(.046)
8	.164		.270 .250	.156 .126	.106 .091	.050 .037	.071 .050	3/64	#56(.046)
10	.190		.313 .292	.180 .148	.123 .107	.055 .041	.083 .060	1/16	1/16
12	.216		.357 .334	.205 .169	.141 .123	.059 .045	.094 .070	1/16	#50(.070)
1/4	.250		.414 .389	.237 .197	.163 .143	.066 .051	.109 .083	5/64	#50(.070)
5/16	.3125		.519 .490	.297 .249	.205 .181	.077 .061	.137 .106		
3/8	.375		.622 .590	.355 .300	.246 .218	.088 .072	.164 .129		

Inactive for design purposes.

*

DASH NUMBERS FOR PLAIN CARBON STEEL SCREWS. FOR DRILLED HEADS & OTHER MATERIALS, SEE BELOW

LGTH.	#0-80	#1-72	#2-64	#3-56	#4-48	#5-44	#6-40	#8-36	#10-32	~~#12-28~~	1/4-28	5/16-24	3/8-24
1/8	0-2	1-2											
3/16	0-3	1-3	2-3	3-3	4-3	5-3							
1/4	0-4	1-4	2-4	3-4	4-4	5-4	6-4	8-4	10-4				
5/16	0-5	1-5	2-5	3-5	4-5	5-5	6-5	8-5	10-5	~~12-5~~	416-5		
3/8	0-6	1-6	2-6	3-6	4-6	5-6	6-6	8-6	10-6	~~12-6~~	416-6		
7/16	0-7	1-7	2-7	3-7	4-7	5-7	6-7	8-7	10-7	~~12-7~~	416-7		
1/2	0-8	1-8	2-8	3-8	4-8	5-8	6-8	8-8	10-8	~~12-8~~	416-8	516-8	616-8
5/8	0-10	1-10	2-10	3-10	4-10	5-10	6-10	8-10	10-10	~~12-10~~	416-10	516-10	616-10
3/4	0-12	1-12	2-12	3-12	4-12	5-12	6-12	8-12	10-12	~~12-12~~	416-12	516-12	616-12
7/8	0-14	1-14	2-14	3-14	4-14	5-14	6-14	8-14	10-14	~~12-14~~	416-14	516-14	616-14
1	0-16	1-16	2-16	3-16	4-16	5-16	6-16	8-16	10-16	~~12-16~~	416-16	516-16	616-16
1 1/8					4-18	5-18	6-18	8-18	10-18	~~12-18~~	416-18	516-18	616-18
1 1/4					4-20	5-20	6-20	8-20	10-20	~~12-20~~	416-20	516-20	616-20
1 3/8					4-22	5-22	6-22	8-22	10-22	~~12-22~~	416-22	516-22	616-22
1 1/2					4-24	5-24	6-24	8-24	10-24	~~12-24~~	416-24	516-24	616-24
1 3/4					4-28	5-28	6-28	8-28	10-28	~~12-28~~	416-28	516-28	616-28
2					4-32	5-32	6-32	8-32	10-32	~~12-32~~	416-32	516-32	616-32
2 1/2									10-40	~~12-40~~	416-40	516-40	616-40
3									10-48	~~12-48~~	416-48	516-48	616-48

ƒ ONLY WHEN SPECIFIED IN NAME & NUMBER

EXAMPLE OF PART NUMBER - 501-6-8 - PLAIN CARBON STEEL
501A6-8 - DRILLED CARBON STEEL
501C6-8 - PLAIN CORROSION RESISTANT STEEL
501AC6-8 - DRILLED CORROSION RESISTANT STEEL
501B6-8 - PLAIN BRASS
501AB6-8 - DRILLED BRASS

MATERIAL - CARBON STEEL SAE-1120 OR BETTER, CORROSION RESISTANT STEEL SPEC. AN-QQ-S-771,
* COMPOSITION FM, BRASS SPEC. QQ-B-611
FINISH - CADMIUM PLATE SPEC. AN-QQ-P-421 CARBON STEEL SCREWS ONLY, PASSIVATE
CORROSION RESISTANT STEEL SCREWS ONLY
SPECIFICATION FF-S-91

REMOVE SHARP EDGES FROM LOCK WIRE HOLES.
THREADS SHALL BE IN ACCORDANCE WITH SPEC. AN-GGG-S-126. SYMBOL NF-2

B/M

AIR CORPS STOCK CLASSIFICATION 29

501

APPROVED	SCREW - FILL. HEAD, DRILLED OR PLAIN HEAD (FINE THREAD)
5-27-30	

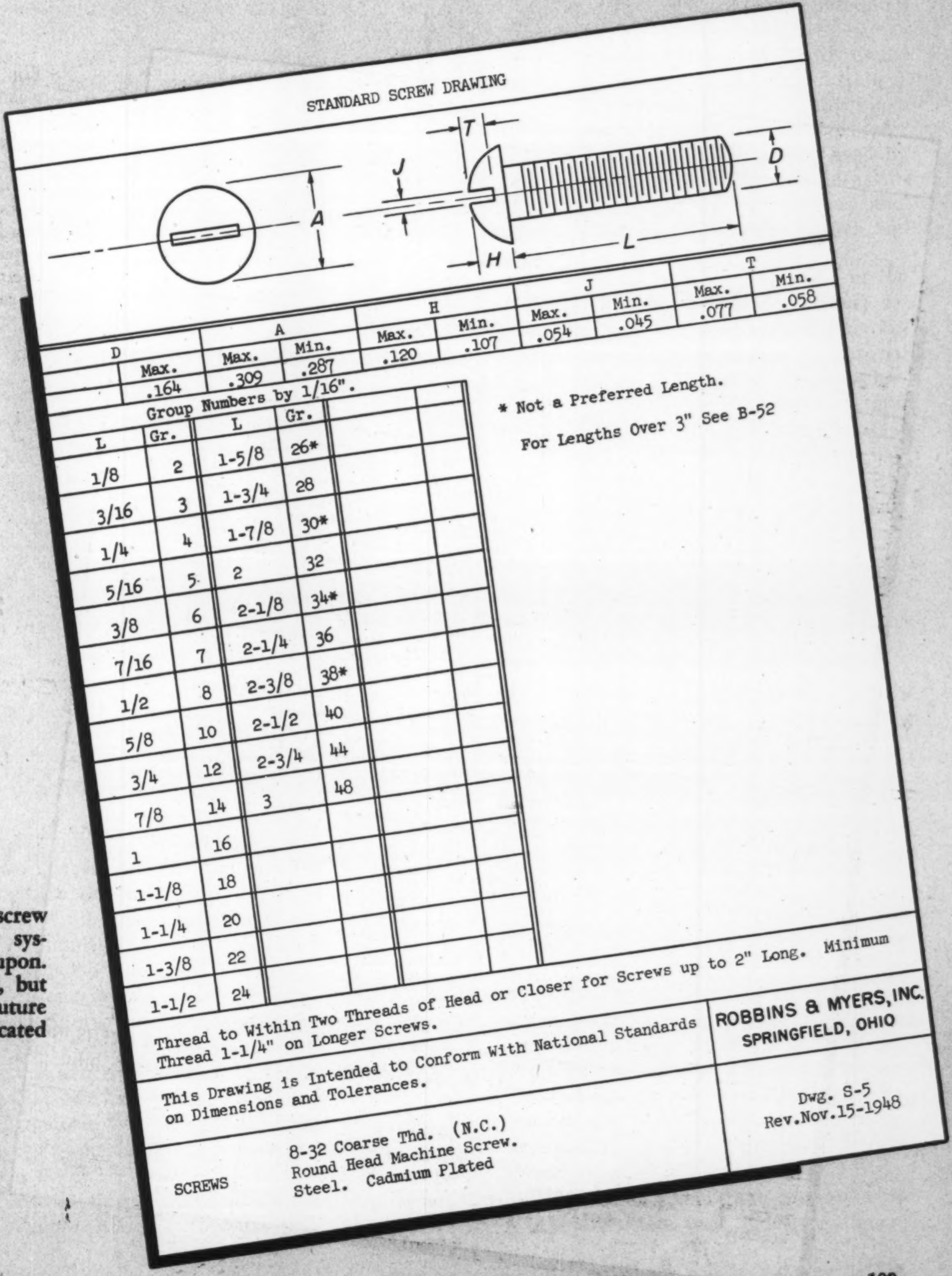
Fig. 2—A different system of specifying screws covers a range of sizes and materials (but one head type) on one drawing, with more complex group system

what became a group resulted primarily from a study of all of the variables pertaining to that type of part. Thus for screws one can list: Head type, diameter, length, class fit, thread series, material, and finish. Or for washers: Basic type, size, and material.

It would be possible, referring to screws, to assume that a designer might be looking for a certain length, and that all screws of that length should appear on one drawing. By this system, the basic drawing numbers would be set up for 1 inch screws, 1½ inch screws, etc. While this is possible, it requires duplication of drawings and dimensional data, and is contrary to basic identification. That is, a designer is more likely to think first of his need for a machine screw, a cap screw, or a split-ring lock washer, thinking of the size next. This basic type becomes the obvious title for a drawing or a group of drawings.

Too much attention cannot be given to the listing of all of the variables before standard drawings are planned. Future needs may readily upset a system inadequately planned without consideration of the modifications or variables of any part.

The drawing identifying the part by number or group should also show dimensions. Only those items



STANDARD SCREW DRAWING

D	A		H		J		T	
Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
.164	.309	.287	.120	.107	.054	.045	.077	.058

Group Numbers by 1/16".

L	Gr.	L	Gr.
1/8	2	1-5/8	26*
3/16	3	1-3/4	28
1/4	4	1-7/8	30*
5/16	5	2	32
3/8	6	2-1/8	34*
7/16	7	2-1/4	36
1/2	8	2-3/8	38*
5/8	10	2-1/2	40
3/4	12	2-3/4	44
7/8	14	3	48
1	16		
1-1/8	18		
1-1/4	20		
1-3/8	22		
1-1/2	24		

* Not a Preferred Length.

For Lengths Over 3" See B-52

Thread to Within Two Threads of Head or Closer for Screws up to 2" Long. Minimum Thread 1-1/4" on Longer Screws.

ROBBINS & MYERS, INC.
SPRINGFIELD, OHIO

This Drawing is Intended to Conform With National Standards on Dimensions and Tolerances.

Dwg. S-5
Rev. Nov. 15-1948

SCREWS

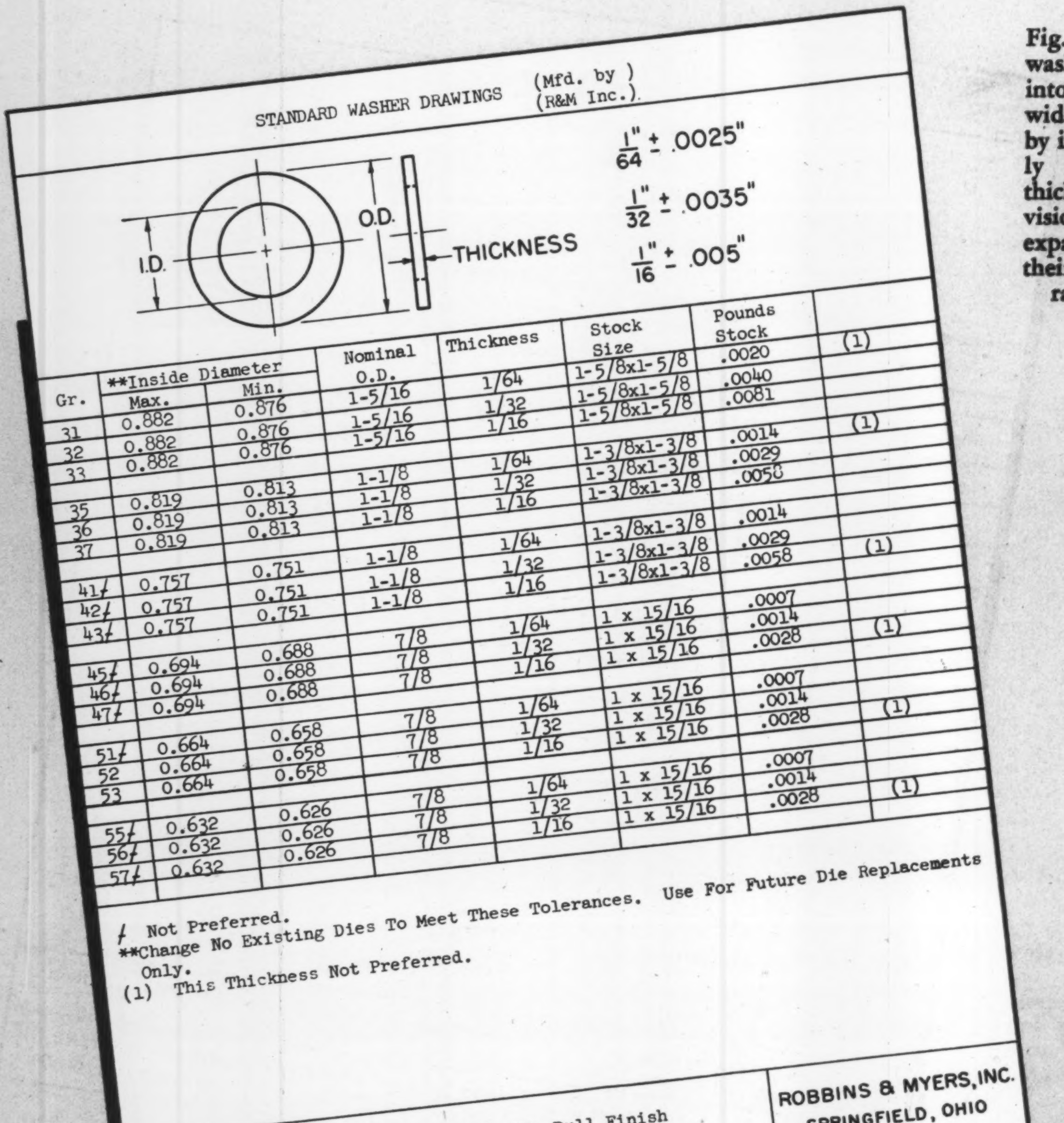
8-32 Coarse Thd. (N.C.)
Round Head Machine Screw.
Steel. Cadmium Plated

Fig. 3—A typical screw drawing showing the system finally decided upon. Several lengths in use, but not recommended for future design, are also indicated

should be put on one sheet which would permit of one sketch, with tabulated dimensions. Thus, two different basic types, say of lock washers, should not appear on one drawing.

The group number should be significant. Even though the entire list of drawings may cover items wherein this is not possible, some inconsistencies are less objectionable than the advantage of significant numbers where they can be used. A good example is a group number for length of screws, bolts, rivets in sixteenths of an inch (as used by the Air Corps) which is an obvious and simple check on a given part, *Fig.* 3. However, a group number for size on a washer, (thus group 4 for those to be used with a No. 4 screw, etc.) is not satisfactory when extended to cover sizes for ½-inch bolts, for instance. In such a case, the group number used need not be obviously significant.

Practical considerations as to the size of drawing helps determine the division between basic drawing and group. Thus *all* round head machine screws of every diameter and length might conceivably be tabulated on one drawing. Obviously a single group number is no longer applicable, as group 16 would cover a 1-inch screw regardless of its diameter. For flexibility, it was decided to use only one diameter on



STANDARD WASHER DRAWINGS (Mfd. by) (R&M Inc.)

I.D.
O.D.
THICKNESS

1" / 64 ± .0025"

1" / 32 ± .0035"

1" / 16 ± .005"

Gr.	**Inside Diameter		Nominal O.D.	Thickness	Stock Size	Pounds Stock	
	Max.	Min.					
31	0.882	0.876	1-5/16	1/64	1-5/8x1-5/8	.0020	(1)
32	0.882	0.876	1-5/16	1/32	1-5/8x1-5/8	.0040	
33	0.882	0.876	1-5/16	1/16	1-5/8x1-5/8	.0081	
35	0.819	0.813	1-1/8	1/64	1-3/8x1-3/8	.0014	(1)
36	0.819	0.813	1-1/8	1/32	1-3/8x1-3/8	.0029	
37	0.819	0.813	1-1/8	1/16	1-3/8x1-3/8	.0058	
41/	0.757	0.751	1-1/8	1/64	1-3/8x1-3/8	.0014	
42/	0.757	0.751	1-1/8	1/32	1-3/8x1-3/8	.0029	
43/	0.757	0.751	1-1/8	1/16	1-3/8x1-3/8	.0058	(1)
45/	0.694	0.688	7/8	1/64	1 x 15/16	.0007	
46/	0.694	0.688	7/8	1/32	1 x 15/16	.0014	
47/	0.694	0.688	7/8	1/16	1 x 15/16	.0028	(1)
51/	0.664	0.658	7/8	1/64	1 x 15/16	.0007	
52	0.664	0.658	7/8	1/32	1 x 15/16	.0014	
53	0.664	0.658	7/8	1/16	1 x 15/16	.0028	(1)
55/	0.632	0.626	7/8	1/64	1 x 15/16	.0007	
56/	0.632	0.626	7/8	1/32	1 x 15/16	.0014	
57/	0.632	0.626	7/8	1/16	1 x 15/16	.0028	(1)

/ Not Preferred.
**Change No Existing Dies To Meet These Tolerances. Use For Future Die Replacements Only.
(1) This Thickness Not Preferred.

ROBBINS & MYERS, INC.
SPRINGFIELD, OHIO

Made From Laminated Phenolic. Grade XP. Dull Finish

DWG. W-40
March 12 1948

BAKELITE WASHERS

For Bearing Spacer On Shafts (Sleeve Bearing) Narrow Washer Series. Supp by W-40; 1-27; 61-87.

Fig. 4—A varied list of washers is broken down into first a narrow and a wide class, then subdivided by inside diameters and lately further subdivided by thickness. Only minor provision had to be made for expansion of the system as their usage was contracting rather than expanding

sheet, as this was thought to outweigh the disadvantages of a double group numbering system, with its increased possibilities of error; it required more individual sheets, of course.

Grouping in steps, or blocks of group numbers, is a useful system. Consider the case of a series of manufactured washers (in contrast to purchased items) representing eighteen different inside diameters. (Used on shafts, they were basically identified by ID rather than OD). Each washer was manufactured in one of three thicknesses of stock. For each different inside diameter there were two different outside diameters. Here was an unusually tangled series of variables.

The problem was to set up a group system using the minimum of drawings in a logical arrangement. The first step was to divide them into two classes, using relative washer widths, wide or narrow. The first drawing, say, is the narrow series. The second variable, establishing a series is the inside diameter; the third as a subseries is thickness. A "block" of group numbers was assigned to each inside diameter, resulting in three drawings all bearing the same number (W-40) as shown in *Fig.* 4. Thus, 108 individual items were identified on two basic drawings, each of 3 sheets, by grouping in steps.

Handling Future Expansion

In starting this new system, data were available on usage on every standard part purchased. An important problem involved the question of listing or indicating items not in use. For instance, button head rivets might be used in large quantities in $\frac{1}{8}$-inch diameters, in lengths of $\frac{3}{8}$ and $\frac{3}{4}$-inch. The standard drawing might be made with only these two sizes shown. With space left for other groups, this might satisfy the demands for future expansion, should another length become necessary. On the other hand, such an addition would require the re-issue of this sheet to all holders of the standards book (approximately 100 in the case at hand).

This repetitive detail work could be avoided by showing at once all standard lengths on the original drawing. This puts complete data on the items in the designers' hands, *but does not channel his usage* into preferred sizes. This emphasizes the need described in the next item.

In most organizations it appears that everyone but the designer is interested in simplifying the number and variety of items which are used in a product! Given a *complete* listing of all sizes and types, various designers may select a multiplicity of items which could better be reduced to one size from the standpoint of purchasing in larger quantities, and simplified stock. It is important, therefore, that some system be set up for indicating four classes of usage on each item. These are: (a) Items which are usually stocked; (b) items which are preferred sizes, but not stocked; (c) items which are standard, but do not fall into either of the above classes; and (d) items which are *not* approved for future design.

One series of standard drawings examined used a circle around the group number identifying the item as being commonly stocked. Details for further classification can readily be planned. However, item (d) deserves further comment. As a "holdover" from old practice, some off-standard items were found which could not be eliminated from production without expensive design changes. Listed in the standard book they could encourage future usage unless properly identified. Nevertheless, if listed, they fulfill the desired effect of *making the standard book an index,* in which each of a selected group of items can be found. On the other hand, omitting a highly special item not approved for future design, and continuing to designate it by the old drawing number, becomes an obvious method of separating standard items from ones which are to be eliminated with future design change. Which method to use poses a question best answered by the needs of an individual organization.

The order of preference of *items* can be indicated as in the foregoing. But any existing organization is likely to find usage broadly spread over many kinds of parts, oftentimes purely through designer's personal tastes. Thus, fillister head screws might be used by some individuals, whereas for the same type of application another designer might use round head and, similarly, with the great variety of set screws and other parts.

While an order of preference could be set up on the individual sheets, in the present case, it was decided to issue supplementary instructions attempting to simplify purchases by designating preferred *classes* of parts. This was correlated with reproductions of stock lists put out by various suppliers, and reproduced as a part of the standard parts book.

Too much emphasis cannot be placed on the importance of trade association and National Standards. Their growth and expansion in recent years affects nearly every fastening device or other item that should be found in a standards book. No such project should be undertaken without making sure that up-to-date copies of such standards are available and used in setting up sizes, dimensions, and tolerances.

Standards change, and the variety of items covered may make it possible to identify a part incorrectly. Suppliers quoting on such an inadvertently wrong item may supply it as a "special" rather than pointing out the nearest standard item. To offset this chance for misunderstanding, all standard parts sheets were set up with this statement: "This drawing is intended to conform with National Standards on dimensions and tolerances."

Developing Company Standards

Obviously there are many items which are not covered by National Standards and which must be specified in a standards book. Headless slotted cup point setscrews are so covered, but a hollow head setscrew with a knurled end for self locking application is not. Co-operation with the purchasing department and possible suppliers is vitally important in trying to set up standards for such latter items.

In some cases, it will be found that a number of suppliers offer the same item with identical dimensions and tolerances, although the part is not covered by any association standard. To give purchasing freedom of sources, such drawings are marked: "This drawing is intended to conform with manufacturers' standards on dimensions and tolerances."

This also indicates on noncritical items that the run-of-the mine commercial product is all that is required and no tolerances need be set up. A good example of such items would be brass washers. No national or trade association standards exist for the "small pattern" or "large pattern" types found in many catalogs. While tolerances on inside diameter are in common agreement, other dimensional tolerances are unknown. Usage was such that these values were not critical, hence the statement concerning "manufacturer's standards" saved needless specifications and restricted buying.

Qualifying Standards Data

In attempting to set up a new series of standard drawings there is a natural tendency to want to "do the job right" with all necessary data specified and defined. The important thing is not to overdo such specifications. A government agency or an extremely large buyer may be justified in setting up certain specifications for material or tolerances on dimensions. To the average buyer, such a procedure may involve an unnecessary restriction. A brass screw, for instance may have such a usage that any alloy used by a reputable supplier could be perfectly satisfactory. Arbitrarily selecting a common alloy and including it with the standards specification may result in unnecessary trouble for a purchasing department. On the other hand, standard steel rivets are supposed to be made of open hearth steel ASA. B18a or equivalent. Listing such data, with the authority of a National Standard behind it may give useful information, not only to the purchaser, but to the designer as well.

Probably one question can be used to determine whether the qualifying data under discussion on a standards drawing is really important or not. That question is: Assume that vital production were being held up for lack of a part which did not meet the specification in question. No serious relaxing of quality must be considered in obtaining a substitute, but under such circumstances, could alternate *B* or *C* be used in place of *A*? If one can conscientiously answer this question in the affirmative, considering all of the factors involved, there is little use in the restrictive specification set up for *A*.

ADMINISTERING THE SYSTEM: Setting up a system for showing standard parts represents only the first step. A second and equally important consideration is the procedure for handling the entire system. In the case at hand, this problem was complicated by the fact that four different engineering departments and a tool design department could be specifying items covered by the standards book.

Obviously additions of new items must not be made by any individual designer or draftsman without supervision. Such supervision can best be given by one responsible engineer. Whether he is a Standards or Quality Control department member, or a designer assigned to such a job as a part of his duties, will vary with different organizations.

The equipment needed for such a job is first, a complete and continuing library of standards, and second a thick skin and a heart of stone! It is to be assumed that any old organization finds its usage of components scattered over thousands of items and growing daily. One purpose of a standards system can be the simplification of that usage. While nominally assigned to the duties of supervising the *additions* to a standards book, it is the real duty of the supervisor to refuse additions. This can be accomplished only if the supervisor refuses to add "group 16" to an existing drawing until the designer has convinced him that a $1\frac{33}{64}$ inch cap screw with a left-hand thread, as requested, is the only possible item which can do the job.

"Policing" the system in a scattered organization is helped by the use of the special drawing numbers for such parts. As the sole holder of such a list, the supervisor readily prevents a careless draftsman from specifying a new standard-sheet item. Assigned a regular drawing number unavailable for other types of design work, the unusual combination is readily caught by a checker, or any other department in the established routine. Lists are also needed, showing the names of all holders of the standards book. Additions and revisions can then be correctly distributed.

A list of all of the classes of components belonging in the standards book is essential. Experience with the system indicated that this original list will be greatly expanded either through broader usage of new items or extension of the system. The proper selection of a group of numbers and the planning of the drawings according to the precepts given here can best be done by one supervisor.

Standard Turbines on Tankers

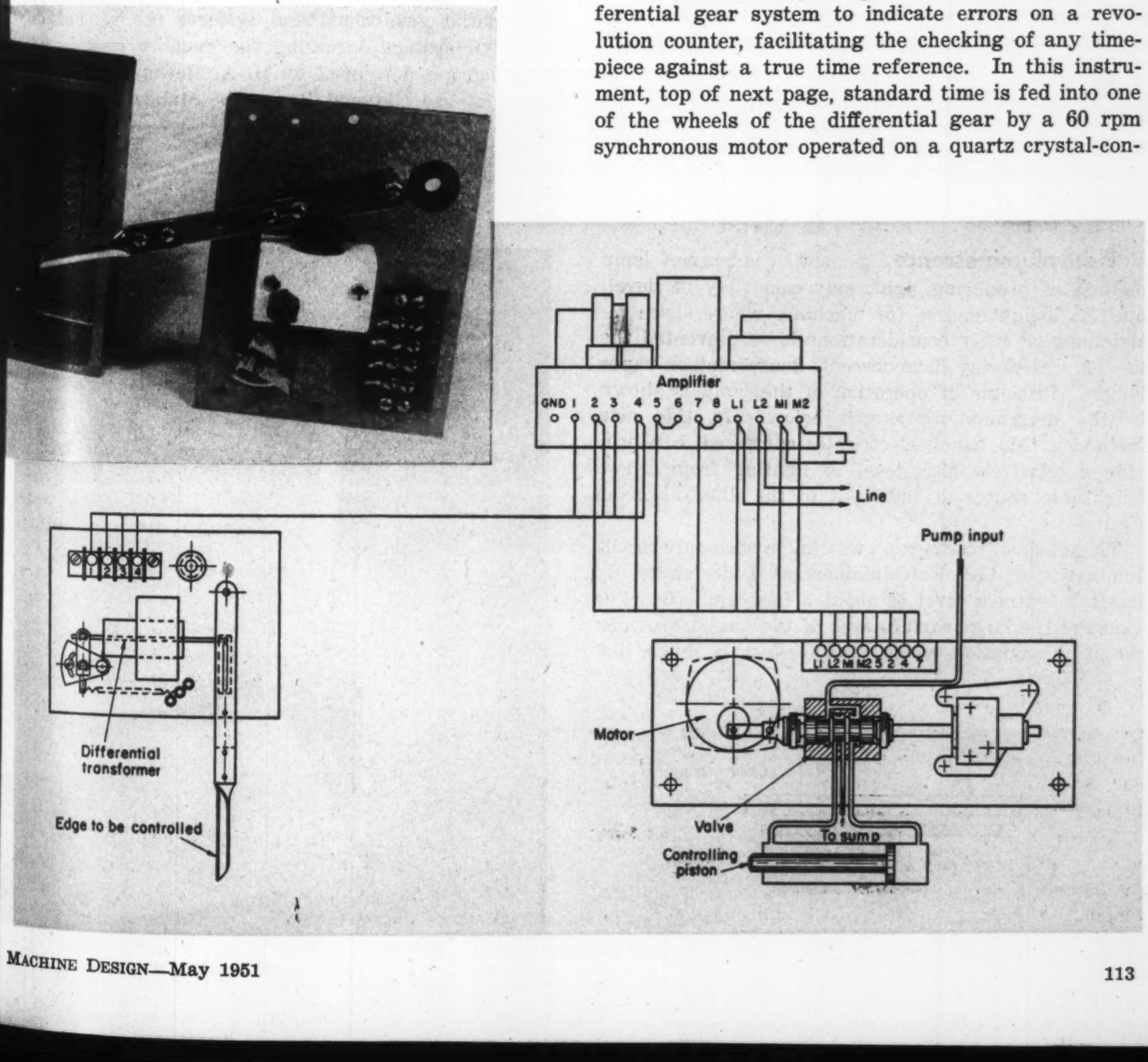
INSTALLATION of eight General Electric DP mechanical-drive turbines for auxiliary purposes on each of five new tankers marks the first marine use of these standardized turbines. The 28,000-ton tankers, of which the S.S. *T. S. Peterson* is the first completed ship, are being built at the Sparrows Point, Md., yard of Bethlehem Steel for Standard Oil Co. of California.

These standard turbines are used for three different applications. Four 500-hp single-stage turbines will be used on each ship to power the cargo pumps; the units operate under steam conditions of 550 psig inlet pressure and 4 psig exhaust, the inlet temperature being 550 F.

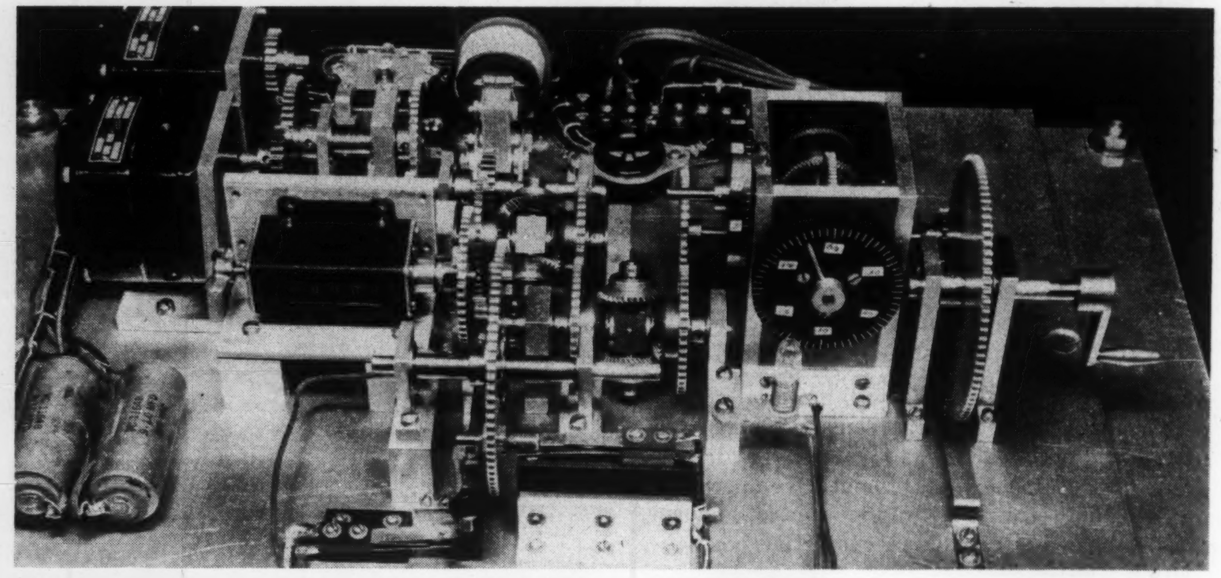
Three 226-hp, 4460-rpm units power the main boiler feed pumps; inlet pressure is 545 psig, exhaust pressure 20 psig, and inlet temperature 505 F. The eighth unit will power the fire pumps and an auxiliary system; this 94-hp turbine runs at 3000 rpm under identical steam and temperature conditions as the main boiler feed pumps.

SCANNING the Field For Ideas

Edge control for registering web material during processing utilizes a mechanical sensing finger and differential transformer, below, to control a hydraulic servo system. Developed by Automatic Temperature Control Co., this electric-hydraulic control, shown schematically below, is capable of corrective positioning to within 0.001-inch over a range of three inches with but ¼-oz pressure on the edge of the web. The fulcrum of the sensing lever is so located that the feeling edge has a 10:1 displacement ratio relative to the transformer armature. The output signal of this transformer is fed through an electronic amplifier to a motor controlling the hydraulic valve. Any change in position of the sensing finger results in a corresponding valve movement to correct the hydraulic piston position. The piston rod, attached to the web guide rail or reel mechanism, keeps the web in register while traveling at 100 yards per minute.


Amplifier
GND 1 2 3 4 5 6 7 8 L1 L2 M1 M2
Line
Pump input
1 2 3 4
L1 L2 M1 M2 5 2 4 7
Differential transformer
Motor
Edge to be controlled
Valve
To sump
Controlling piston

Correction-computing chronograph employs differential gear system to indicate errors on a revolution counter, facilitating the checking of any timepiece against a true time reference. In this instrument, top of next page, standard time is fed into one of the wheels of the differential gear by a 60 rpm synchronous motor operated on a quartz crystal-con-

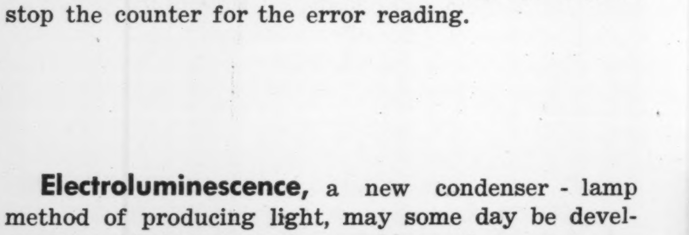


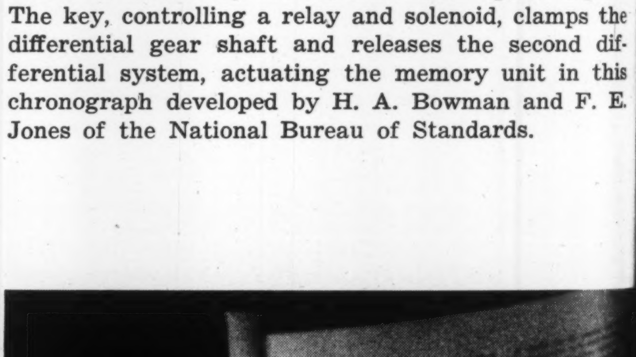
trolled frequency accurate to one part in 50 million. The time indicated by a timepiece or watch under test is introduced into the second wheel of the differential so that the position of the differential shaft is proportional to the difference between an indicated time period and standard. Because mechanical connection of a watch to the system is not feasible, an input signal is manually introduced by a crank and is indicated on a dial calibrated in minutes and seconds. When the watch indicates the time shown on the dial, the operator presses a telegraph key to stop the counter for the error reading.

To avoid loss of time in the standard gear wheel, a memory device in the form of a second differential stores the motion of the synchronous motor while the counter is stopped. When the telegraph key is released after reading, the memory differential automatically transfers its stored time to the counter and resets to zero ready for the next interruption signal. The key, controlling a relay and solenoid, clamps the differential gear shaft and releases the second differential system, actuating the memory unit in this chronograph developed by H. A. Bowman and F. E. Jones of the National Bureau of Standards.

Electroluminescence, a new condenser - lamp method of producing light, may some day be developed as a light source for machines where space restrictions or other considerations have prevented the use of present-day incandescent, fluorescent or vapor lamps. Principle of operation of the lamp is shown in the diagrammatic sketch below. In this new method a thin panel, electrically energized, can provide a relatively high level of lighting from a low brightness source as indicated in the illustration at right.

This unusual photograph was taken with only the illumination of the electroluminescent device shown. It has a brightness level of about 3 foot-lamberts. Because of the large surface area of the unit it provides direct illumination which in its effect is much like



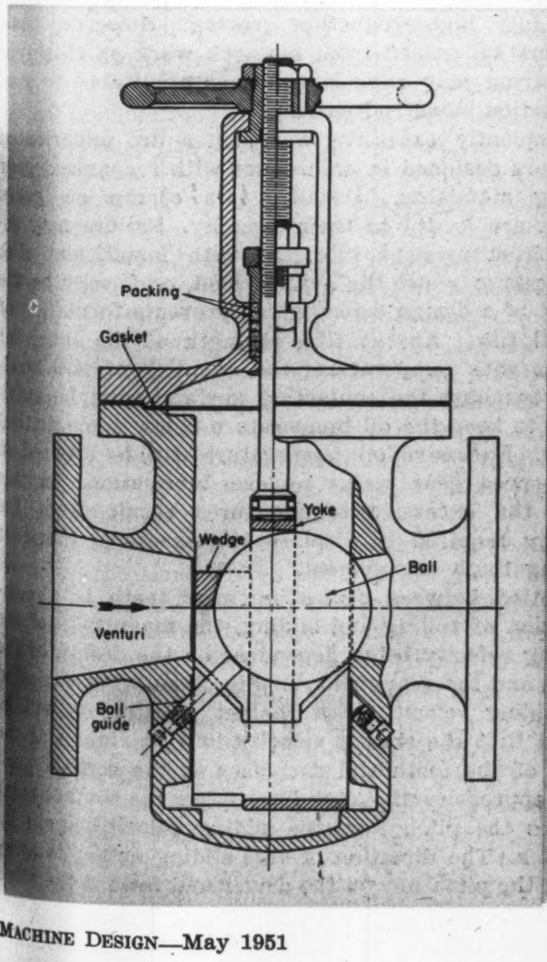


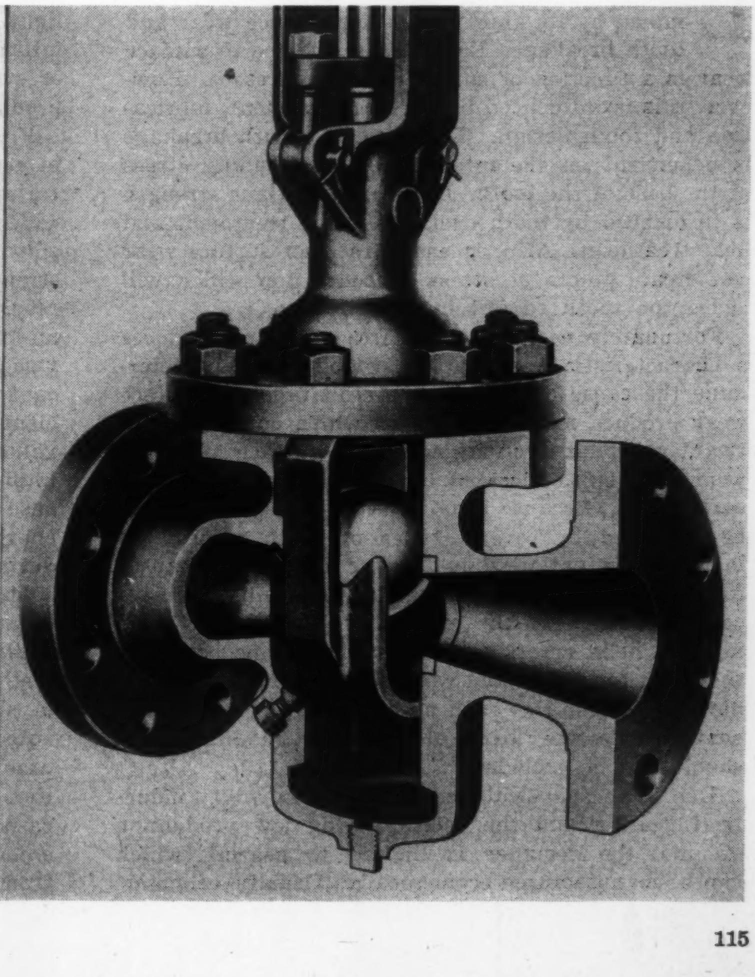
indirect lighting. Research on this new lighting method has been conducted by Messrs. Payne, Mager and Jerome of Sylvania Electric Products Inc., who have produced relatively high lighting levels with panels as large as two by three feet, operated on commercial frequencies and voltages. The units having the greatest light output are, however, green. Other colors including yellow and red have been successfully demonstrated in small sections but are effective only when relatively high frequencies (5000 to 8000 cps) are applied. It is interesting to note that the lamp producing green at 60 cycles becomes blue-white at 3000. The light emitted is proportional to the power consumed, varying with the voltage and frequency. Brightness values of at least 20 foot-lamberts have been attained in these experiments.

Electrical energy is converted into light by the action of a pulsating electric field upon a suitable phosphor dispersed in a dielectric. Intermediate phenomena, such as a gaseous discharge or cathode-ray bombardment, are not involved and no gas-tight envelope is necessary. The absence of intermediate phenomena gives the method simplicity, flexibility and possibility of economy. The lamps tested at Sylvania are made by spreading a thin film of phosphor, dispersed in a light-transmitting dielectric, onto conducting glass. A metallic backing is then applied, leaving a margin for insulation. Electrical connections are made to a metallic strip along one edge of the glass and to the metal backing.

Ball valve, below, utilizes Bernoulli's principle in that the ball centers itself in the flow stream during valve closing. Designed by the Paul Valve Corp., the valve has venturi inlet and outlet passages to increase the velocity of the fluid flowing through the valve to suck the ball against its seat, making a tight line-contact seal. A ball guide, as shown in the drawing of the valve in closed position, is fixed in the valve body to position the ball during closure against the seat. Also, a wedge member in the valve-stem yoke mechanically seats the ball and holds it securely regardless of pressure and flow conditions in the system.

During opening, the yoke raises to lift the wedge and then bring fingers up to roll the ball from its seat. In full open position, both the yoke members and the ball are removed from the stream to give the valve unimpeded full-flow characteristics. Rotation of the ball during valve operation presents a new seating surface upon each closure to increase the service life of the ball. Throttling action is virtually a straight-line characteristic from full flow to closed.





GEARS

. . . improving the resistance of heavy-duty gearing to service damage

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LOAD carrying capacity of a gear set is determined by its ability to resist surface wear and tooth breakage. Basically, resistance to surface wear is a function of surface contact stresses. However, this is influenced by surface treatment, lubrication and tooth design. Resistance to tooth breakage is dependent on the intensity of the bending stress at the base of the tooth. In turn, the fatigue strength is influenced by tooth design, surface treatment and heat treatment. Also, excessive rates of surface wear can create points of stress concentration which will cause the tooth to fail in fatigue, *Fig.* 1.

Fortunately each type of surface failure produces a characteristic wear pattern which can help determine the cause of the wear. As all types of surface wear produce metallic particles which enter the lubricant and tend to create additional surface wear, the wear may be accelerated if it is not detected in its early stage. Because some types of surface wear can be produced by several types of tooth errors, the initial investigation should cover all possible causes for condition observed. Usually they will require a complete check of the gear teeth for profile, spacing and helix errors together with and inspection of the teeth for finish and workmanship. Naturally, the obvious possibilities such as a misalignment between shafts, excessive loads and insufficient lubrication should not be excluded.

Due to the physical size of most heavy-duty industrial gearing and the accompanying low production volume, the designer is limited to gearing which can be manufactured economically. Usually, economic considerations eliminate some of the designs used in light-duty high-production gearing. However, basic information gained from research work on this type of gearing may suggest solutions applicable to low-production industrial gearing.

Frequently excessive wear rates are experienced in gears designed in accordance with recognized gear rating standards. Usually, this occurs on gears which are loaded to their capacity. Failure may result from using a lubricant with insufficient film strength to resist the applied load, or it may be the result of a design defect which prevents formation of an oil film. As the film strength of the lubricant varies with temperature, the quantity of the lubricant reaching the contacting surface must be sufficient to keep the oil temperature below some critical value. Excessive oil temperature can be created in high-speed gear trains by over-lubrication. In this case the excessive temperatures result from the energy required to displace the excessive lubricant during tooth engagement.

Motion between contacting gear teeth is a combination of rolling and sliding, the magnitude of the sliding velocity being dependent on the design of the teeth and the gear ratio. In *Fig.* 2, showing variation in sliding velocity with contact position, it will be noted that the sliding velocity is a maximum at the base of the tooth and decreases as the contact position approaches the pitch line. After the contact point passes the pitch line, the sliding velocity again increases. The direction of this sliding action is away from the pitch line on the driver and toward the pitch

Fig. 1—Left—Teeth on this gear failed because deflection in the system caused nonuniform load distribution

Fig. 2—Below—Sketch showing sliding velocity of gear teeth with respect to the pitch line of the gear

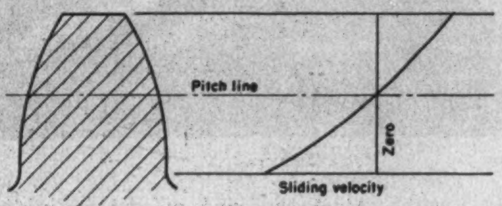
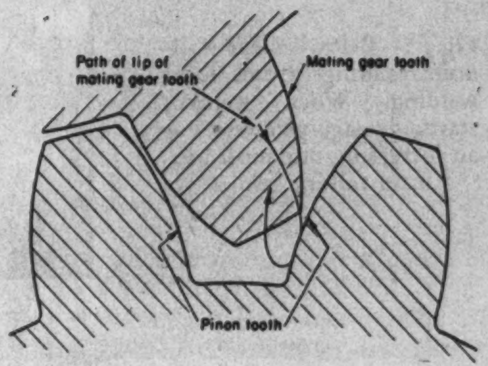


Fig. 3—Below—Approach path of gear tooth tip showing duration of tip contact with pinion



line on the driven member in a gearing system.

If the oil film is ruptured by scraping action resulting from tooth profile errors, extensive general wear may occur. If the film is ruptured momentarily by an impulse load, the resulting wear will be less severe because the film will be re-established. Minor tooth profile errors and surface irregularities can cause a momentary rupture of the oil film which will be repaired when the point of contact has moved to a more advantageous location. This type of wear is usually corrective, as it results in the offending points being worn off. Tooth profile and spacing errors can create high instantaneous rates of acceleration which may create high dynamic loads. These high instantaneous loads can cause a momentary failure of the oil film and limited localized wear. In all of these cases, the wear will be of an abrasive or rubbing off nature, and the first signs of wear should appear in the zone of maximum sliding.

One mild but malignant type of abrasive wear can occur on the flank of the pinion tooth as a result of the action of the gear tooth during its approach to the pinion tooth. The path of the tip of the gear tooth as it approaches and meshes with the mating pinion tooth is shown in *Fig.* 3. In this illustration it will be noted that the tip of the gear travels very close to the flank of the pinion prior to its engagement with the pinion. If the tip of the gear tooth is sharp, it will scrape the lubricant from this portion of the pinion tooth and contact will occur on relatively dry surfaces.

If the gear contains either spacing or profile errors, the tip of the gear tooth will scrape the flank of the pinion tooth during approach, and the sharp edge of the gear tooth will tend to wear the flank of the pinion tooth. This type of defect will cause the teeth to wear at a rapid rate. If the gears containing this defect have commercially acceptable involutes and good surface finish, wear will produce very fine metallic particles suspended in the lubricant. This type of wear can be prevented by providing the gear teeth with a chamfer or radius.

In the event of a general oil film failure, the tooth surfaces will deteriorate at an accelerated rate and show signs of local welding. This type of failure is known as scuffing, scouring or galling, *Fig.* 4. In this illustration it will be noted that the tooth faces are scored radially and show evidence of peening. The radial score lines were caused by local welding, and the peening by the entrapment of metallic particles between the teeth. A more drastic example of this type failure is shown in *Fig.* 5. In its early stages this type of failure will appear as radially scored grooves starting at the base of the tooth and running toward the pitch line. The edges of these initially scored grooves form additional high points to puncture the oil films and cause additional local welding. This surface roughness creates local points of high temperature, decreasing the load capacity of the oil film and accelerating the deterioration of the tooth surfaces. In some cases this type of wear can be prevented by using a lubricant with a higher film strength. However, in the more critical cases a mild extreme-pressure lubricant must be used. These

Fig. 4 — Right — Oil film rupture caused the characteristic welding failure of this herringbone gear

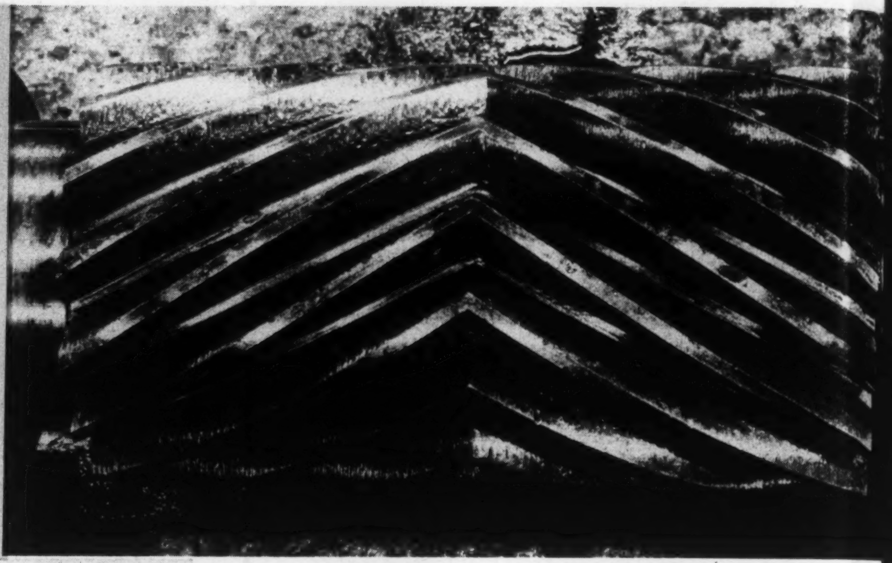
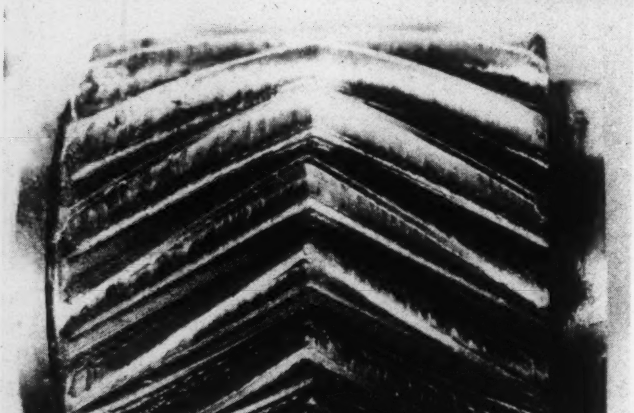


Fig. 5—Below—Gear failure resulting from local welding. When welding starts, damage progresses at an increasing rate until ultimate failure results



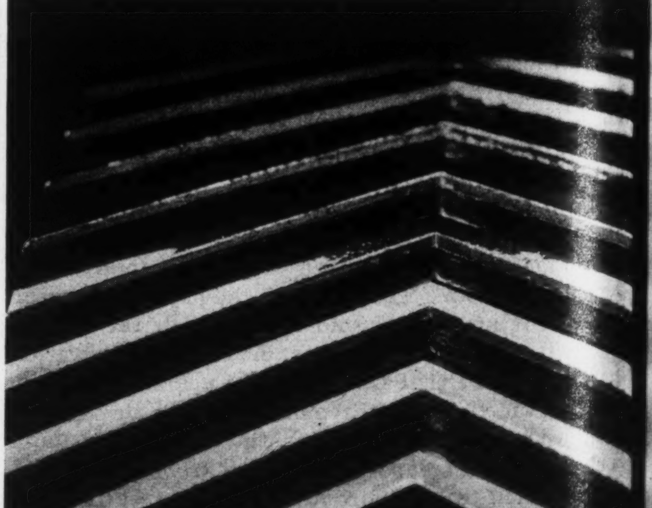
lubricants contain agents which form antiwelding films on the tooth surfaces and materially increase their resistance to galling or welding. If this type of wear is detected in its early stages, it is probable that the gears can be salvaged by cleaning the metallic particles from the gear housing and changing the lubricant to a mild extreme-pressure lubricant.

One of the most common types of tooth wear is pitting. Experience has shown that pitting is influenced by the film strength and cleanliness of the lubricant. The phenomenon of pitting has been classified in two categories, and, while the conditions causing them are similar, the end results are different. Initial pitting can be classified as a corrective procedure which occurs during the wearing-in process and disappears during the course of normal wear. In a case of this type small pits will develop gradually on the tooth face below the pitch line. After a limited number of these small pits have developed the pitting process will be arrested and normal wear will gradually remove them.

If the pitting is progressive or destructive, the pits will develop in the same manner but at a more rapid rate. Also, the size of the individual pits will be greater. In this case the size and number of pits will continue to increase until the entire tooth profile below the pitch line is destroyed. A short addendum gear which was destroyed by pitting is shown in *Fig.* 6, and a section of a long addendum pinion which was destroyed by pitting is shown in ***Fig.*** **7**. Each of these elements was removed from speed reducers which had been severely overloaded.

Buckingham[1] has explained the phenomenon of pitting as a combination result of plastic flow of the surface layer of the gear tooth and subsurface shear stresses developed by tooth contact. Plastic flow of the surface layer of the gear tooth results from the combination rolling and sliding motion between the mating teeth, causing the surface layer to travel in the direction of rolling. In this case the material

Fig. 6—Progressive pitting caused failure of this short addendum gear. Damage occurs below the pitch line



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[1] References are listed at end of article.

tends to travel as a wave in front of the roller as shown in *Fig.* 8. Naturally, when sliding exists in combination with rolling and its direction is the same as that of rolling, the rate of surface movement will be increased, *Fig.* 9.

This plastic flow of the surface layer work hardens it, increasing its resistance to plastic flow. Sometimes this results in the formation of small surface cracks and the repetitive nature of the tooth action causes these cracks to propagate. If the lubricant becomes trapped in the cracks, it will tend to lift out small particles of the material, developing small surface pits. This type of pitting is usually classified as initial pitting and is not detrimental if the rate of surface strengthening from the cold working is sufficiently rapid to arrest the surface cracking process.

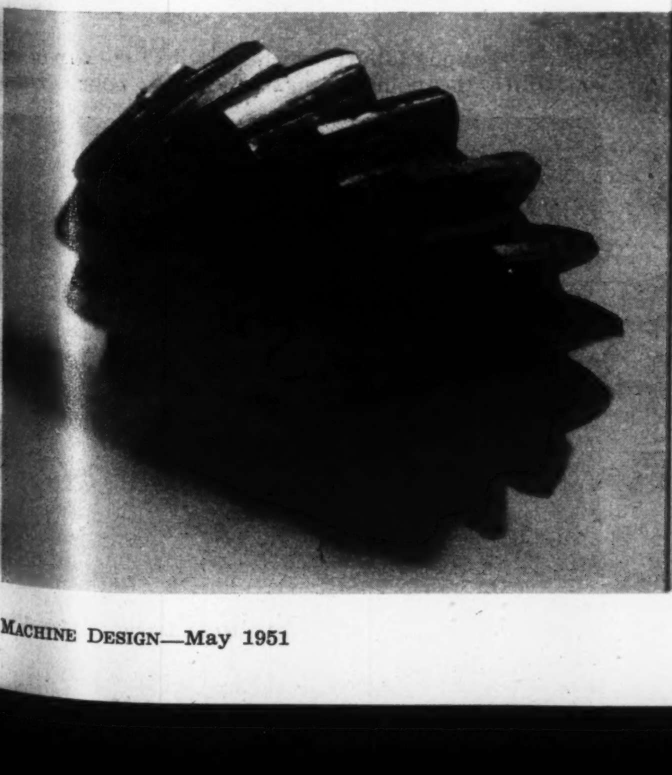
If tooth loading is excessive, high subsurface shear stresses resulting from contact between the curved tooth surfaces will develop subsurface cracks parallel to the surface. If this process is accompanied by the development of surface cracks, the conditions required to produce destructive pitting are established. Cracks and small pits will be repeatedly formed on an expanded scale. The pits will become larger and deeper and the tooth profile will be destroyed if it is not arrested. In general, pitting is usually confined to the dedendum section of the profile as shown clearly in *Figs.* 6 and 7.

Practical experience with gears has shown that pitting is influenced by lubrication, and that the vulnerability of the gears to pitting increases as the viscosity of the lubricant is decreased. This would seem to indicate that the hydraulic action of the lubricant in the small surface cracks might be the sole cause of pitting. However, experience has shown that pitting can be arrested and eliminated by changing the lubricant from a straight mineral oil to an extreme-pressure (EP) lubricant of the same viscosity. This practical observation would indicate that the probable beneficial result attained from EP lubricants are the result of decreased friction because a decrease in the magnitude of the sliding friction force would decrease the rate of plastic flow in the surface layer of the tooth. Some recent experimental work conducted to determine the cause of service pitting in tractor gears has exposed another factor which can cause gears to pit. This work^2 has shown that gears using a lubricant contaminated with dirt are more susceptible to pitting than gears having clean lubricant.

Although surface failures are the most common, heavy-duty precision-cut industrial gearing is not immune to tooth breakage. Pitting can cause breakage. Because pitting does not occur uniformly over the tooth face, it disrupts the theoretical load distribution and tends to eliminate conjugate tooth action. Disruption of the load distribution will increase the magnitude of the bending moment imposed on the tooth. Also, pitting creates sharp-cornered depressions near the root of the tooth which act as points of stress concentration in the zone of maximum bending. These combined adverse effects of pitting have caused tooth breakage failures and, in these cases, the point of origin of the fatigue crack was a deep pit.

Economic pressure and technical advances in machining of metals have been responsible for a gradual

Fig. 7—Pitting failure of a long addendum gear which was overloaded in service



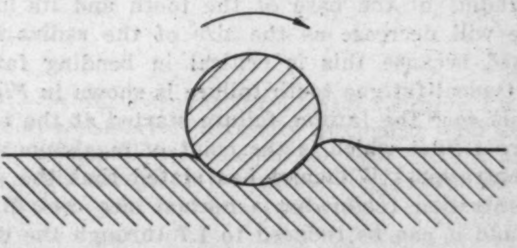
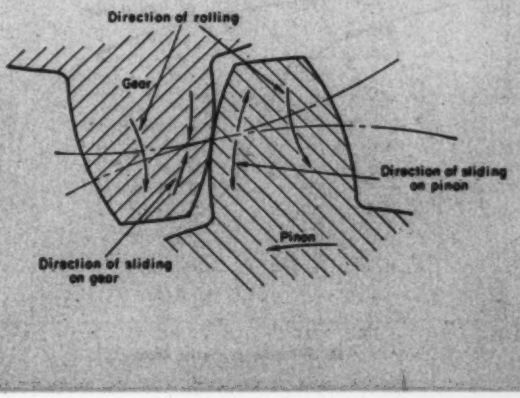


Fig. 8—Above—Sketch showing combination action of rolling and sliding to produce plastic flow of surface layer

Fig. 9—Below—Direction of rolling and sliding motions during engagement of gear and pinion

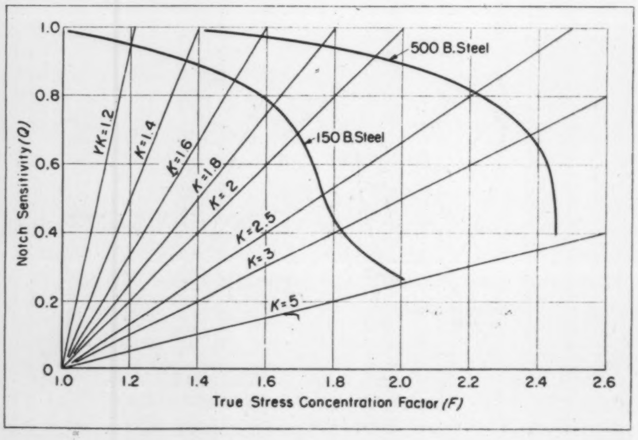


increase in the hardness of through-hardened gears. As a result of this trend, tooth pressures have increased, introducing requirements for lubricants with higher film strengths. Technical advances in lubricant have kept pace with this requirement. Some of the gear tooth design concepts, however, have not. When the hardness of a material is increased, its ability to adjust itself to local stress conditions is reduced. The harder steels are more affected by a given stress raiser than are the softer steels. This fact is dynamically illustrated by *Fig.* 10, which was shown by Johnson and Lipson[3].

In *Fig.* 10, *K* is the theoretical stress-concentration factor, *F* is the true stress concentration factor and *Q* is a factor used to account for the difference between the theoretical stress-concentration factor and the actual factor determined in fatigue tests. If the quantity *Q* is equal to 1, the stress-concentration factor is equal to the full value of the theoretical stress-concentration factor. If it is equal to zero, the material is not stress sensitive. As this analysis is based on properly heat-treated materials, heat treating errors which decrease the impact strength of the material will tend to magnify the adverse effects of stress concentration. Probability of the existence of this type of error increases as the material hardness is increased. The probability of the existence of this condition can be decreased by using materials with higher hardenability, particularly when high hardness is desired in heavy sections. Naturally, the importance of this effect will depend on the design of the radius at the base of the tooth and its importance will decrease as the size of the radius is increased because this is critical in bending fatigue.

A typical fatigue tooth failure is shown in *Fig.* 11. In this case the fatigue failure started at the top of the root fillet which is the point of maximum stress concentration. Williams[4] has stated that the stress concentration factor for a normal size root fillet is 3.5, and it can be reduced to 1.7 through the use of a full radius at the tooth root. This theoretical information and experience suggests that a larger than normal root radius is desirable on heavy-duty gearing when the higher hardness ranges are used.

Fig. 10—Notch sensitivity plotted against stress concentration factor showing that harder steels are more sensitive to stress raisers



Maximum practical root radius size is dependent on the process used to produce the teeth. The top of the fillet radius must be kept slightly below the active portion of the tooth profile. This clearance should be sufficient to allow for shop variations with a reasonable margin of safety. Maximum fillet size may be limited by the type of tooth tip required on the cutter to produce the radius. In certain types of generating processes, the necessity of maintaining a minimum width land on the top of the cutter tooth limits the maximum practical radius. If the top land on the cutter tooth is reduced below this critical value, the life of the cutter will be adversely affected.

Because the shafts and housings supporting the gears are not perfectly rigid, their deflections preclude the possibility of uniform load distribution over the gear face. These deflections usually occur in a manner which places the maximum tooth pressure on the edges of the gear face. If the face widths of the gear and pinion are equal, this condition can induce high bending stress in the pinion teeth and may cause them to fail in fatigue. A typical failure of this type is shown in *Fig.* 1. The intensity of the bending stresses in the pinion teeth due to this condition can be reduced by making the face width of the pinion greater than that of the mating gear. Then the magnitude of the stress at the edge of the tooth is reduced, and the possibility of failure is lessened.

Solutions to all types of gear failure problems require careful examination of the damaged part and a complete review of the history of the part. The review should include an analysis of the applied load and a careful review of the gear manufacturing processes. In too many cases the engineer designs a gear to do a specific job but fails to follow through on the manufacturing processes to find if factors are introduced which are unfavorable to performance.

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2. R. P. Van Zandt and B. W. Kelley—"Gear Testing Methods for the Development of Heavy Duty Gearing," presented at 1949 Semiannual meeting of AGMA.
3. P. O. Johnson and C. Lipson—"Fatigue Strength of Steel Parts," *Product Engineering*, Oct., 1947.
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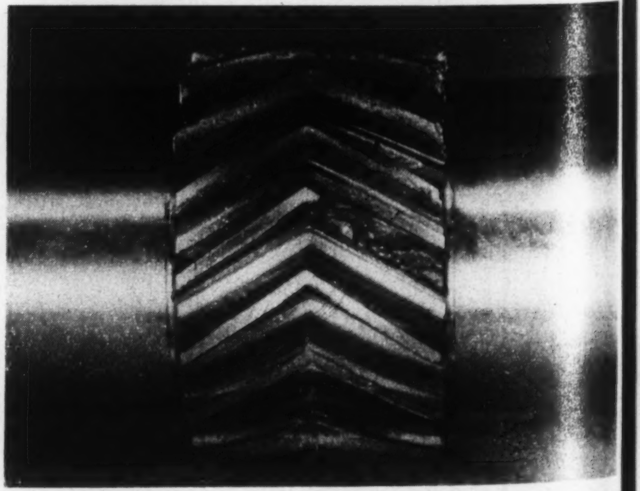
Fig. 11—Fatigue failure which started at the top of the root fillet, the point of maximum stress concentration



Designing Beryllium Copper Investment Castings

In the interests of manufacturing economy, the possibilities of investment cast beryllium alloy should be carefully investigated

By John T. Richards
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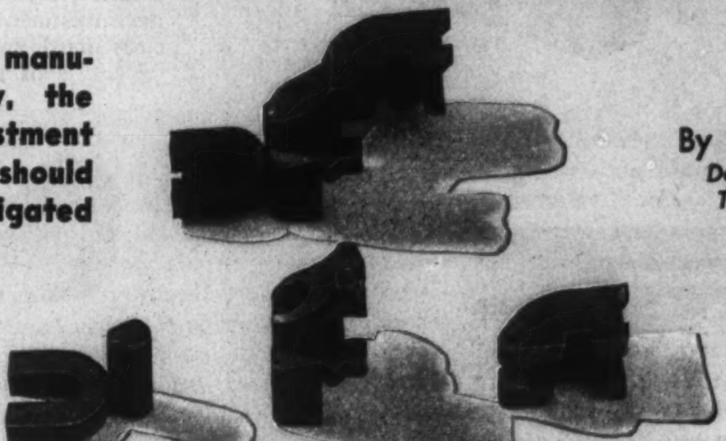


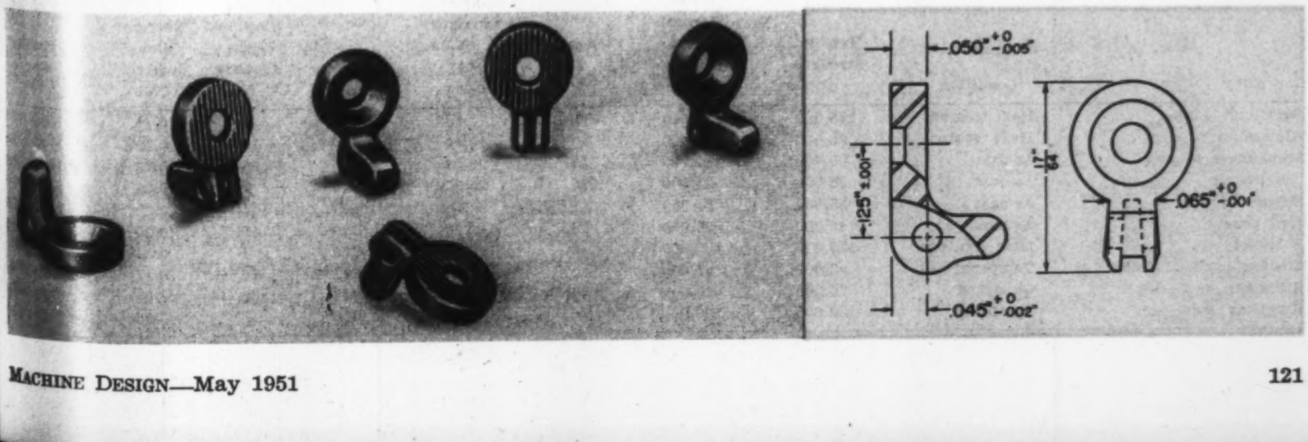
BERYLLIUM copper is finding increased use as an investment casting material for the production of a wide range of industrial parts. The unexcelled casting characteristics of this alloy permit flexibility of design with important cost saving opportunities, and beryllium copper castings develop through age hardening the same useful properties as wrought materials.

On the basis of experience, reasons for choosing a beryllium copper investment casting can be summarized as follows:

1. To take full advantage of the many useful properties of beryllium copper in the engineering of new designs
2. To replace parts or assemblies fabricated by other production methods where the combination of

Fig. 1—In this assembly for a textile machine, excellent abrasion resistance is necessary to combat wear at high speeds, as several strands enter the wide end and emerge as a single thread at the narrow end. Parts are engineered to fit closely as cast without machining

Fig. 2—One of the smallest castings ever produced, this part was formerly machined from extruded steel stock, but machining presented a handling problem because of size. Beryllium copper provides a tolerance of ± 0.001 inches on the ⅛-inch distance between hole centers, permits sections as thin as 0.050-inch and gives minute detail as exemplified by the serrations



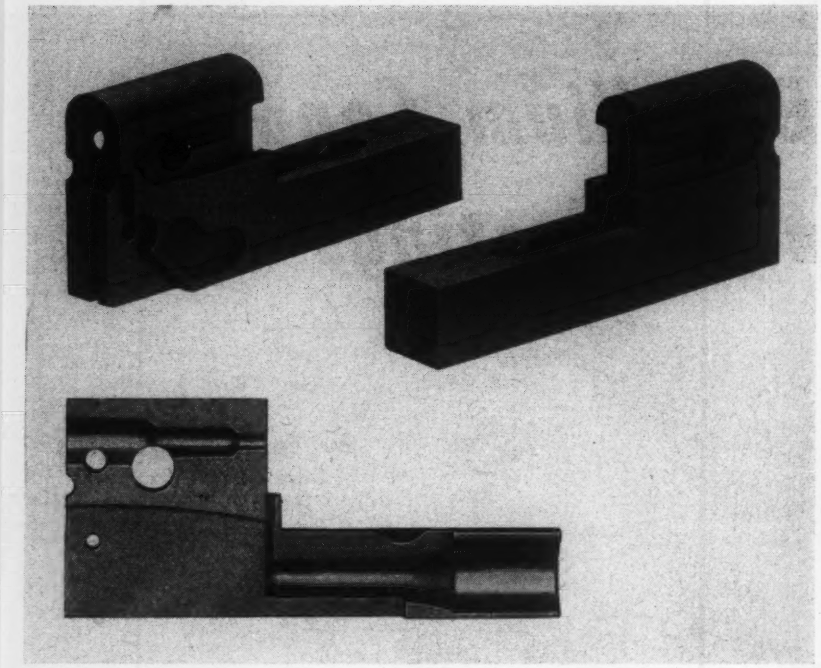
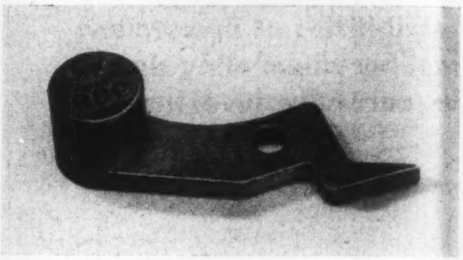


Fig. 3—A .22 caliber rifle bolt precision cast from beryllium copper with tolerances as close as ± 0.002-inch on certain dimensions and requiring no machining other than gate removal. Beryllium copper was selected to combine thick and thin sections and sufficient detail to eliminate an additional part

Fig. 4—Formerly this part for a paper box machine was assembled from two toolsteel pieces; however a beryllium copper investment casting was found sufficiently hard and made possible a saving of 10 cents per part



beryllium copper and investment casting means the lowest cost consistent with good operation

3. To replace other investment casting materials for lower cost or better performance.

Beryllium copper parts find use in communication, textile, aviation, electronic, business machine, firearm, instrument, ordnance, paper processing and miscellaneous electrical and mechanical applications, *Fig.* 1.

The following section lists the features and limitations of investment casting; subsequent sections deal with the advantages, design considerations, engineering properties and processing characteristics of beryllium copper.

WHY INVESTMENT CASTING? Investment casting, sometimes known as the "lost-wax process", is a relatively new method for producing small precision parts. This much publicized World War II development has now become a useful production tool in the industrial field. Through accurate reproduction of detail without machining, investment cast parts are frequently not only cheaper but may also include design features not otherwise attainable.

The degree of intricacy available in "as-cast" parts reduces substantially or may even eliminate expensive machining, *Fig.* 2. Consequently, as-cast dimensions often do not require finishing to meet tolerances. Projections, recesses, irregular holes, external undercuts and other details which ordinarily present difficulty in fabricating can usually be incorporated into the casting, *Fig.* 3.

Optimum design freedom is obtained through wax welding in the pattern stage, making possible final parts that could not otherwise be readily produced. Several components or subassemblies can be combined to give a single unit with improved appearance, reduced weight and greater strength or rigidity at lower total cost.

Compared to other production methods, the tooling cost for investment castings is relatively low. The choice between permanent and soft metal dies is governed by several factors. Although soft metal dies, made from a model, are economical and provide a rapid method of preparing samples, they are recommended only for short runs of simple pieces. Permanent dies, fabricated from steel or aluminum in a way which permits design changes to be incorporated at very little cost, are necessary for long runs and

Table 1—Several Investment Casting Alloys Compared

Alloy	Condition	Tensile Strength (psi)	Yield Strength (0.2% Offset, psi)	Elongation (in 2 in.) (%)	Compressive Strength (0.001-in. Set) (psi)	Hardness (Rockwell)	Electrical Conductivity (% IACS)	Thermal Conductivity (CGS)	Melting Range (F)
Beryllium copper	Heat treated	175,000	150,000	2	175,000	C40	22	0.29	1585-1780
Aluminum bronze	Heat treated	90,000	50,000	10	40,000	B90	14	0.19	1900-1950
Manganese bronze	As cast	80,000	40,000	25	24,000	B75	18	0.22	1660-1740
Tin bronze	As cast	35,000	25,000	20	20,000	B70	7	0.09	1500-1800
Silicon bronze	As cast	55,000	30,000	18	20,000	B65	7	0.09	1775-1875
Red brass	As cast	40,000	25,000	25	11,000	B20	15	0.20	1810-1840
S Monel	Heat treated	125,000	105,000	2	110,000	C36	3	0.06	2300-2350
Medium-carbon steel	Tempered	95,000	65,000	25	40,000	B92	11	0.17	2700-2760
Stainless steel—304	Quenched	75,000	45,000	55	......	B73	2	0.04	2550-2650
Stainless steel—410	Tempered	120,000	100,000	20	......	B98	2	0.06	2700-2790

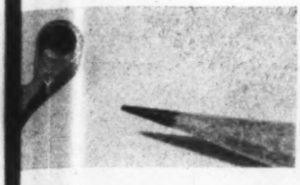


Fig. 5—This investment-cast push pawl replaced an assembly of two stampings plus a separator. Beryllium copper was selected since it furnished the required mechanical properties with a 25 per cent cost saving over a similar steel investment casting

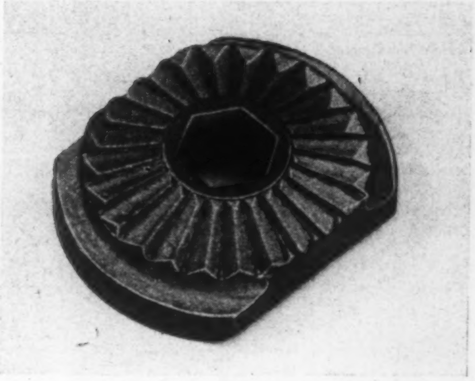


Fig. 6—This index shaft button for an aircraft instrument replaces a similar nickel-alloy precision casting. The added castability of beryllium copper provides the fine definition required on the teeth with appreciably lower scrap losses

for parts of intricate design.

The low cost of tooling makes small quantities, as low as a few hundred pieces, practical even though the price per piece may be considerably higher than other methods requiring a high tooling charge. Consequently pilot lots are often investment cast to make test runs before final dimensional approval is given, due to the low cost of changing tooling. In addition, short runs can be cast to test new markets with minimum initial tooling investment. Since set-up time is a minor factor, buyers may avoid heavy inventories by specifying delivery of small quantities at regular intervals and still secure a low price.

All these advantages are readily available through investment casting techniques, but some caution should be observed to prevent misapplication. Among available founding methods, it is considered a precision process; however, the degree of dimensional accuracy cannot compare with that obtainable through precision machining. In addition, investment casting cannot compete pricewise with screw machine or sand cast parts requiring few finishing operations, *Fig.* 4.

Although relatively simple or symmetrical shapes can be produced faster and cheaper by automatic machining methods, investment casting may offer short-run economies where screw machine parts would require special set-up or equipment. Even where simple machined, stamped, die-cast, or sand-cast parts may offer the lowest overall cost, investment castings may be employed to take advantage of design features not otherwise attainable, *Fig.* 5.

Castings are usually limited to small sizes, since competitive advantages decrease as overall dimensions increase. Parts under ½ pound are most suitable and although much heavier pieces (up to 10 pounds or 7 inches along the greatest dimension) are possible, they are expensive and often not practical. Sand castings lack the precision or dimensional control obtainable in small investment castings; in large parts, however, sand castings provide equivalent accuracy at lower cost. On the other hand, the minimum size for investment castings has, as yet, not been determined.

WHY BERYLLIUM COPPER? This alloy generally owes its selection to favorable casting and mechanical properties. Where final properties may be of secondary importance, beryllium copper is frequently specified for its excellent casting qualities, *Fig.* 6. By virtue of relatively low pouring temperature and good fluidity in the molten state, it is especially adaptable to investment casting.

Since beryllium copper is an age-hardening alloy, the tensile strength of solution-annealed castings can be readily increased from 65,000 to 170,000 psi by means of a simple, low-temperature heat treatment. In addition to high strength and hardness, this alloy retains the corrosion-resistant, nonsparking and nonmagnetic characteristics of copper. Other properties include good electrical and thermal conductivity as well as excellent resistance to wear and moderately elevated temperatures. With decreasing temperatures (at least to −370F), increases over room temperature ultimate and yield strengths combined with no loss of ductility or shock resistance suggest good service with no embrittlement in subzero atmospheres. TABLE 1 affords a comparison among several casting alloys.

The relatively low pouring temperature of beryllium copper combined with its good castability offers the following advantages over steel:

1. About 33 per cent more parts per flask
2. Scrap loss considerably lower
3. Pieces with section changes more easily cast
4. Not susceptible to hot shortness frequently encountered in similar steel castings
5. Extensive thin sections more readily filled
6. Cleaner holes and slots
7. Lower melting point makes possible the use of a more desirable investment
8. Lower melting point reduces gas absorption, insuring smoother surfaces and no blowholes
9. Less shrinkage in heavy sections.

By virtue of these advantages, beryllium copper frequently offers the lowest overall cost. Compared to other copper-base alloys, beryllium copper parts are stronger and give better resistance to wear and

Table 2—Composition of Alloy 20C

(Percentage by weight)

Beryllium	1.90-2.15
Cobalt	0.35-0.65
Silicon	0.20-0.35
Iron	0.25 max.
Aluminum	0.15 max.
Tin	0.10 max.
Lead	0.02 max.
Zinc	0.10 max.
Nickel	0.20 max.
Chromium	0.005 max.
Copper	remainder

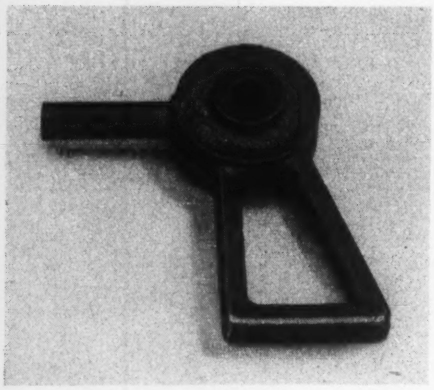


Fig. 7—A single casting which replaced a three-piece assembly of spring steel on an electric counter of a paper box folding machine. In addition to savings in initial cost, the cast beryllium copper unit insures dependable operation through increased rigidity

Fig. 8—Originally a die casting, this part was changed to a beryllium copper investment casting to provide the strength required. Age-hardening beryllium offered easy machining in soft or solution-annealed condition and good strength and hardness by low-temperature aging procedure easily effected

elevated temperatures. Operating temperatures may run as high as 500 F without appreciable loss of hardness. In addition, the good running qualities of beryllium copper make possible gating off a thin section to fill a heavy section, thereby offering under special conditions simplified gating and certain design advantages.

Although there are available several special-purpose materials, the most widely used beryllium copper alloy for investment casting work is known as 20C and has the composition given in TABLE 2. Alloy 20C meets the requirements of Navy Specification 46C11 for beryllium copper precision castings. It is available in the form of 3-oz, 2½-lb and 5-lb ingots. The 3-oz size is especially convenient in investment casting work to facilitate handling in small batch melting.

DESIGN CONSIDERATIONS: The designer should work in close contact with the foundry, since—as previously pointed out—best results are obtained when parts are designed to take full advantage of the potentialities of the investment casting process. Tolerances carried over from old designs should be reconsidered and liberalized where possible to reduce costs. In designing, remember that:

1. *Size* affects the price materially, so that large protruding sections should be eliminated
2. *Tolerances* can be held to ± 0.004-inch per inch. Closer tolerances can be maintained for certain dimensions, depending upon the size and shape
3. *Distortion* may be a factor on long thin parts, so that some allowance may be necessary
4. *Surface finish* can be held to 65 to 80 micro-inches
5. *Ribs or crowns* should be used on large flat areas
6. *Wall thicknesses* as light as 0.030 to 0.050-inch are possible, depending upon surface area. Although thicknesses run up to ½-inch, ribs are preferred for added strength
7. *Draft* should be eliminated, since it is not necessary and only increases tooling costs
8. *Parting lines* should be straight
9. *Radii* on outside corners should be eliminated when possible, because they increase tooling cost. A $\frac{1}{32}$ to $\frac{1}{16}$-inch fillet on inside corners assists metal flow
10. *Internal undercuts,* while sometimes possible, are undesirable and can usually be machined as a secondary operation at lower cost
11. *Sections* should be as uniform as possible, since abrupt section changes may leave shrinkage cavities and are detrimental to metal flow. The use of slots, holes or ribs is preferred over heavy sections
12. *Holes* as small as 0.020-inch may be produced in light sections. Although through holes are preferred, blind holes of certain sizes are possible
13. *Shrinkage* averages $\frac{3}{16}$-inch per foot (1½ per cent).

Table 3—Typical Physical Properties for Alloy 20C

(Age-hardened condition)

Specific gravity	8.09
Density, lb per cu in.	0.292
Magnetic properties	Nonmagnetic
Melting range, F	1585–1780
Shrinkage, in. per ft	3/16
Specific heat, cal./gm/C, 30-300 C	0.10
Maximum increase in density on heat treatment, %	0.6
Maximum decrease in length on heat treatment, %	0.2
Elastic modulus in tension	18,500,000
Average coefficient of linear expansion	
Per deg C, 20-200C	0.000017
Per deg F, 68-392F	0.000009
Electrical conductivity, % IACS	20–25
Electrical resistivity, microhm cm	6.6–6.9
Thermal conductivity	
Btu/sq ft/ft/hr/F	650–800
Cal/sq cm/cm/sec/C	0.22–0.28

In addition, some consideration should be given to mating assembled parts, because they may be cast as a rigid unit without increased cost, *Fig.* 7. To meet certain accuracy and economy requirements, it may be advisable to finish grind, ream or tap by machine, rather than depend upon tolerances or threads as cast.

PHYSICAL PROPERTIES: TABLE 3 lists typical physical properties for this alloy, age-hardened.

MECHANICAL PROPERTIES: Average mechanical properties, including tensile strength, elongation and hardness are given in TABLE 4. This table shows the effect of heat treatment upon mechanical properties.

Service temperatures are generally limited to 500 F, since prolonged exposure to higher temperatures causes appreciable softening. As previously indicated, beryllium copper experiences no loss of impact strength at subzero temperatures.

CORROSION RESISTANCE: In general, beryllium copper resists corrosion in a manner similar to high-copper alloys. Under normal conditions it offers good resistance to industrial and marine atmospheres,

Table 4—Average Mechanical Properties of Alloy 20C

Properties	As Cast	Cast and Heat-Treated (2 hr. @ 650 F.)	Cast and Solution-Annealed	Solution-Annealed and Heat-Treated (2 hr. @ 650 F.)
Tensile				
Ultimate tensile strength	75–85,000	90–110,000	55–70,000	155–185,000
Proportional limit (0.002% offset)	20–30,000	25– 40,000	10–20,000	100–130,000
Yield strength (0.01% offset)	25–35,000	30– 45,000	15–25,000	110–140,000
(0.20% offset)	40–50,000	45– 65,000	20–40,000	130–160,000
(0.50% strain)	30–45,000	35– 55,000	20–40,000	55– 85,000
Elongation, % in 2 in.	16–29	10–25	30–50	1–3
Reduction of area, %	15–30	10–25	20–40	0–3
Rockwell hardness	B80–90	B90–100	B60–80	C38–45
Brinell hardness, (approx)	150–185	185–240	107–150	352–426
Compressive Properties (0.001 in. Set)	....	....	....	160–180,000
Endurance Strength at 10,000,000 cycles	....	....	....	20– 30,000
Izod Impact Strength	60–80	45–65	80–110	5–14
Electrical Conductivity (% IACS)	12–17	17–22	10–15	20–25

fresh and salt water, most alkaline solutions, and some acids. Although this alloy in time stains and darkens as does copper when exposed to humid and sulfur bearing atmospheres, tarnish does not noticeably affect mechanical properties.

Beryllium copper has poor resistance to ammonia, sulfur, mercury and many of their compounds. In acids, its behavior is similar to deoxidized copper. Dezincification and hydrogen embrittlement apparently do not occur. In addition, this alloy offers excellent resistance to corrosion-fatigue and salt water cavitation or erosion.

OTHER CONSIDERATIONS: The properties listed herein result from inspection or laboratory tests; consequently, some care should be exercised in attempting to incorporate these values in design work. Safe working stresses depend upon type of load (static or endurance) and operating conditions, so that design stresses derived from engineering properties should be used only when the part can be readily subjected to stress analysis. Even when working stresses are within limits prescribed to prevent yield or fatigue, adequate allowance must be made for high localized stresses induced by corners, notches, holes, etc.

In using beryllium copper in place of some other material, it is generally not advisable to make a direct substitution. Best results are obtained through redesigning to take full advantage of available properties and to allow for changes in working stress, conductivity, modulus, etc.

HEAT TREATING: Optimum properties are obtained by a two-step thermal treatment. The first, or solution-annealing operation, softens the material. The subsequent low-temperature aging treatment hardens the parts to give the desired combination of properties. Machining, when necessary, should follow annealing and precede aging, *Fig.* 8. Since beryllium-copper is readily ground in any condition, castings are generally finish ground after hardening.

Parts should be annealed for one hour per inch or fraction of inch of section thickness at 1450 to 1475 F, then immediately water quenched. Castings are then hardened by heating for three hours at 650 F, followed by cooling at any convenient rate. Circulating air furnaces give good results in either heating operation. Salt baths are not recommended, since the irregular shape makes cleaning difficult.

For applications in which increased ductility or added resistance to shock are of greater importance than maximum strength and hardness, an overaging heat-treatment may be used, *Fig.* 9.

Where maximum strength is not required, the "cast and heat-treated" condition offers time and cost saving opportunities through fewer operations. Cast parts are furnace hardened for three hours at 650 F, followed by uncontrolled cooling.

SURFACE FINISHING: Investment cast parts are generally sand or shot blasted following aging to give a uniform surface. This finish, with or without light buffing, usually provides the final one.

Where coloring is desired to meet service requirements, generally accepted processes may be applied. In beryllium copper firearms parts which must match blued steel however, standard coloring solutions do not provide the required shade. Consequently, it may be necessary to apply a 0.0002 to 0.0003-inch iron plating which can then be blued conventionally.

The author acknowledges the assistance of Hitchiner Manufacturing Co. in making available data and illustrative material included in this article.

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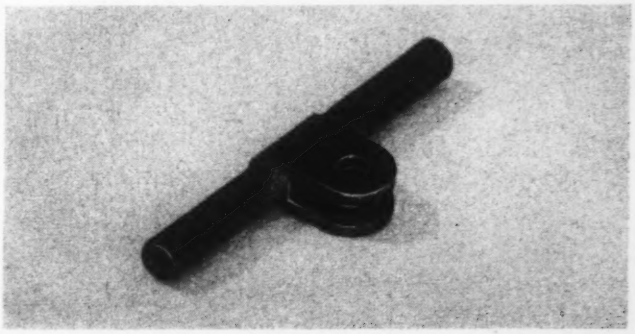
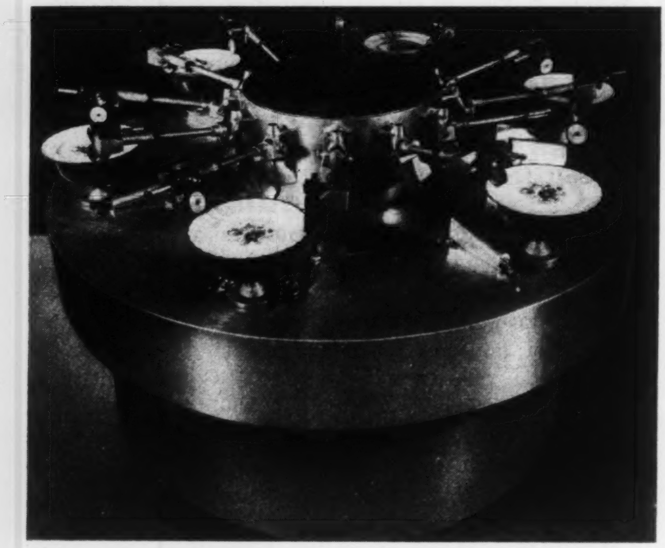


Fig. 9—Investment-cast hinge part for a portable radio aerial eliminates a two-piece assembly which did not stand up in service. The beryllium copper casting is given a special aging treatment for the right combination of strength and shock resistance

Flexible Shafting Solves Drive Problems

FLEXIBLE shafting may be the solution to simplified, low-cost power transmission or remote control in many drive and control applications. When properly applied, this type of drive often can do the same job as more complicated systems such as bevel and worm gears, universal joints, and other angle drives. In addition to low initial cost, flexible shafting requires minimum assembly time, resulting in low assembly and maintenance expenses.

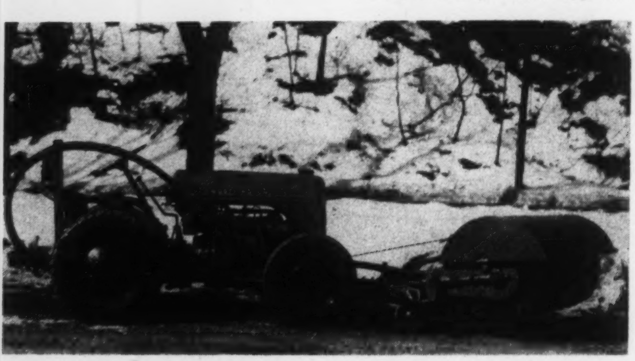


Photo, courtesy S. S. White Industrial Div.

Fig. 1—Edging machine for chinaware, made by Rykman Machine Co., utilizes flexible shafting to each of the twelve arms, permits ample vertical movement of arms and wide horizontal adjustment range

Fig. 2—Tractor-powered road brush is driven by heavy-duty flexible shafting. Low production made this drive most expedient

Photo, courtesy Elliott Mfg. Co.



An application in which flexibility of the drive shafting was a prerequisite is a chinaware edging machine for rolling a colored border on dinnerware, *Fig.* 1. It was necessary to provide drives for the arms, which are mounted to the dome, to allow them to ride up or down on the scalloped edges, to move in or out for various size plates or to be raised clear of the plates. Twelve power drive flexible shafts driven from a planetary gear inside the dome are used, providing a vibration-free drive at speeds varying from 50 to 150 rpm.

Production Rate Important

A multiple concrete vibrator to produce a uniform compactness in stiff concrete mixes uses high-speed vibrating heads. These heads, operating at speeds of over 9500 rpm, are driven by motors mounted on a bar in back of the unit. Here, ¼-inch diameter power drive flexible shafts couple the motor spindles and driving heads. Isolating the motors from the heads not only protects the motors from vibration but also reduces the amount of dead weight on the heads.

A low production rate, about 10 per year, did not warrant design of an elaborate drive for the tractor brush attachment, *Fig.* 2, and a separate gasoline engine drive was not justified. This troublesome alignment problem was solved by using a 1 3/16-inch power drive flexible shaft operating from the tractor power take-off to the 30-inch diameter by 6-foot long brush at speeds varying between the extremes of 600 to 1000 shaft rpm.

A drive to a high-speed pump from a large marine engine involved problems of alignment and expense. In this application, a 1½-inch diameter power drive flexible shaft transmits 55 hp at 2700 rpm through a 90-degree bend, driving a speed increaser with an output of 11,300 rpm. Because of the high horsepower and speed, the flexible shaft was lubricated by a circulating oil system.

Power transmission shafting is, in general, made for rotation in one direction only—opposite to the lay of the inside layer of wire. If it must operate in both directions, the shafting should be chosen large enough to carry the load in the reverse or "against-the-lay" direction. Shafting for remote control applications is specially wound, usually with more wires than power shafting, and permitting slow-speed rotation in either direction.

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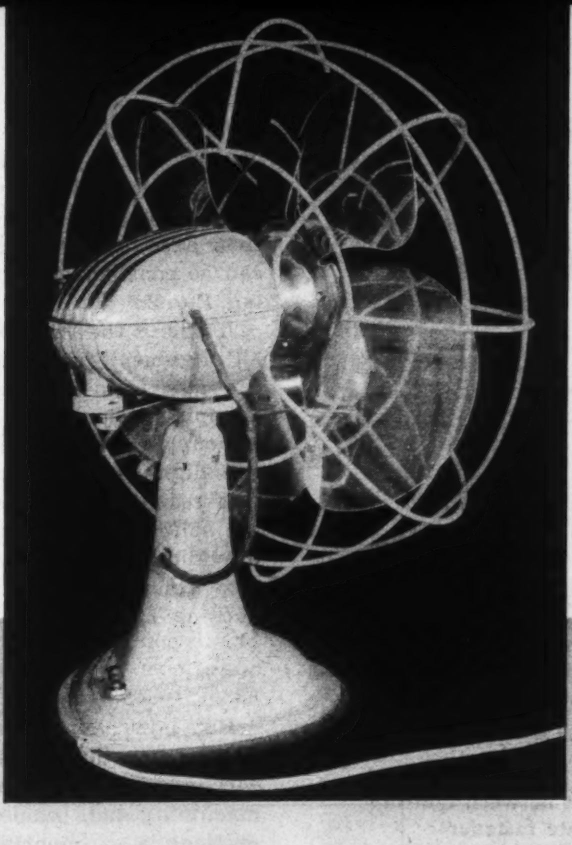


Fig. 1—Fan illustrates the possibilities of designing for lower production costs

DESIGNING AN *Electrical Appliance*

. . . to utilize production possibilities of diecastings

DESIGN for lower cost but more quality! This challenge, often hurled at design engineers, is a difficult assignment especially for a product that has undergone extensive development for many years, such as a desk fan, *Fig.* 1.

In designing for a low cost product, the first requisite is a mental divorce from conventional design practices. Wherever possible, new design and production methods should be considered. The next step is creation of a remodeling plan that sets forth general objectives. Application of this plan to the particular case, as was done with this new fan, makes the program jell: (1) Select best-suited materials—use die-cast aluminum-alloy motor housings for dimensional stability, lightness, and decorative value; (2) integrate parts—combine gear case with one of the housings (upper or lower); (3) strive for simplicity—eliminate slide cores so multicavity molds and low-cost flash-trimming operations are possible; (4) reduce machining operations—cut to minimum the ma-

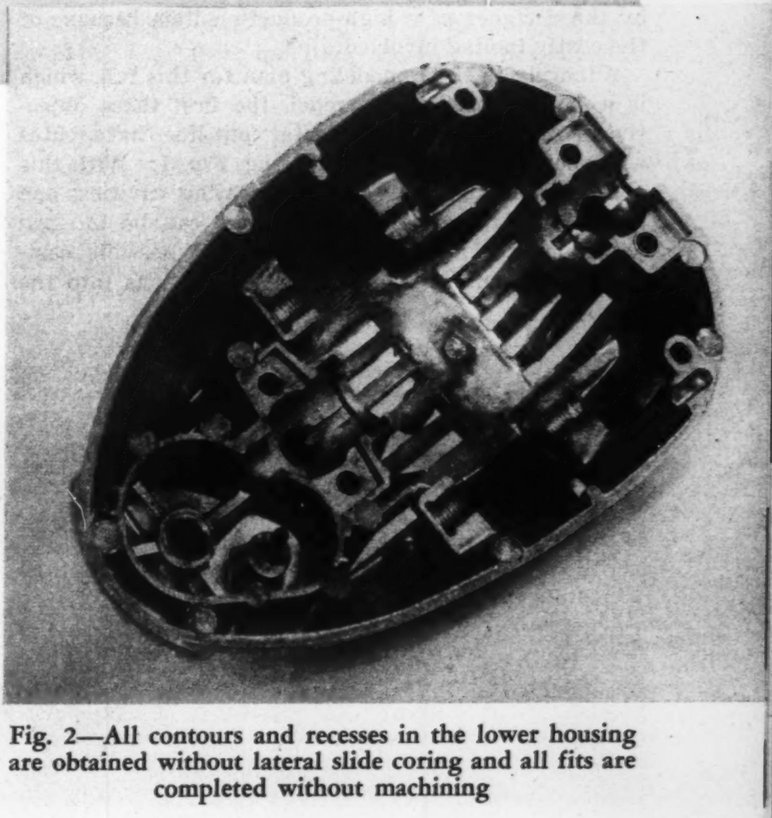


Fig. 2—All contours and recesses in the lower housing are obtained without lateral slide coring and all fits are completed without machining

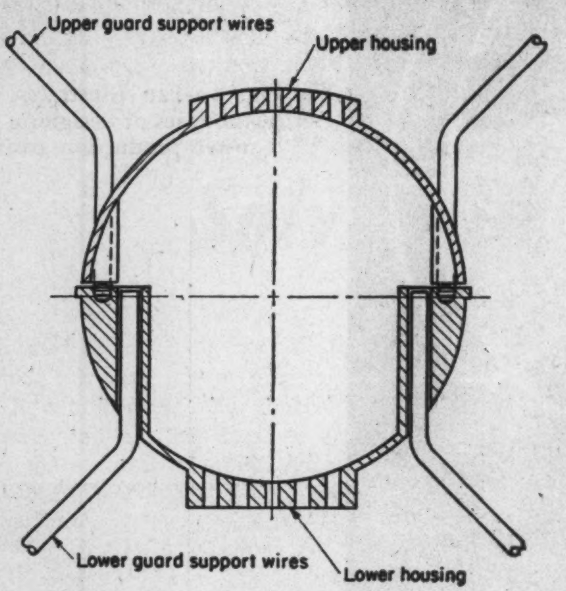


Fig. 3—Clamping guard wires between housing castings obviates separate fasteners

chining of housings for alignment of rotor and stator; (5) facilitate serviceability—reduce the number of screw fastenings and, for sales appeal, conceal them; and (6) simplify assembly operations—provide maximum accessibility plus minimum need for fixtures.

A thorough study of the product should be made so that all design possibilities may be exploited. A search of this nature should always be undertaken by the designer of a high-production item because of the costly tooling involved.

Adhering to the remodeling plan for this fan, which is a 12-inch oscillating model, the first three objectives point to use of a horizontal split line that creates an upper and lower motor housing, *Fig.* 1. With this construction, the gear case, lubricating cavities, and seats for stator and rotor bearings can be integral with the housing castings. To make possible casting of the centers of all oscillating motions into the lower housing without use of slide cores, spur gears must be employed for the second reduction. Thus, the first-reduction gear stud and second-reduction gear sleeve, as well as the oscillating stud, all have their axes parallel to the path of mold separation and can be considered as inserts cast in the bottom housing, *Fig.* 2.

If one of the two housing halves is relatively rigid, all alignment functions can be conferred upon it and the less rigid housing half need serve only as a clamping member and cover. Because the lower housing supports the oscillating gears, it logically becomes the alignment member for the stator and rotor. For this reason it is given increased rigidity by raising the split line above the horizontal axial plane and by providing a thick rim around the outer edge. This also conceals any slight mismatching of the two housing halves at the split line.

Coining Corrects Alignment

But how may variations in shrinkage and distortion of the die-cast lower or alignment housing be corrected? The shape of the part does not favor machining and, besides, elimination of machining operations is an important objective. If the rotor-bearing and stator seats are cast with serrated surfaces, however, a coining die can press these surfaces into alignment with respect to the second-reduction gear center. This can be combined with the trimming operation of the heavy outer edge so that cold-work strains in shear help set the housing in alignment. Diecasting alloys best suited for this purpose are those having more than three per cent elongation to insure good flow of the serrations under the coining pressure.

Provision of ventilating holes through the housing wall is a difficult problem because most attempts to show openings made without slide cores, avoiding interference with the gear case and other obstructions, result in an unacceptable appearance. However, interrupted parallel-slot openings in the axial direction can be concealed by providing aluminum projecting stripes on the outside of the housing. With such a design the appearance can be enhanced by polishing the aluminum stripes, after painting the casting, to bring out six parallel bright metal lines.

Instead of separate fastening of the blade guard, a

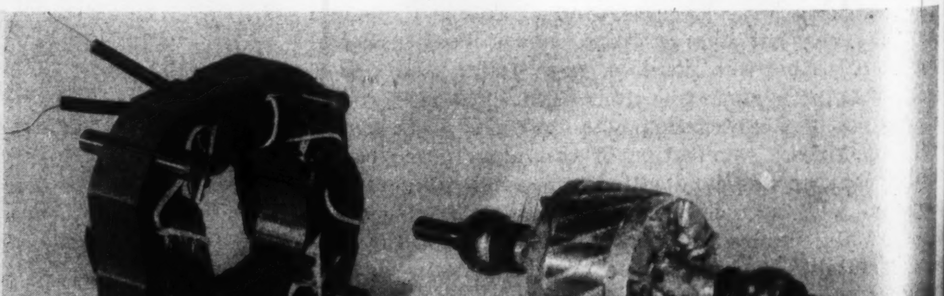


Fig. 4—Stator and rotor ready to be dropped into lower motor housing

conventional procedure that destroys appearance, a combination of strain and clamping action is used to hold the guard in a concealed manner, *Fig.* 3. Two parallel vertical holes are cast in the lower housing for two lower guard supporting wires and two parallel horizontal seats are cast in the outer edge of the housing for two upper supporting wires. The lower wires enter the cylindrical holes and slide upward, the upper wires slide around and over the housing into the horizontal seats. The wires are held tightly in place, partly because of the strain of their natural misalignment, and partly because the upper supporting wires are formed in curves and are forced into straightened horizontal positions in their seats by the clamping action of the two housing halves.

The stator seats shown in *Fig.* 2 consist of four serrated cylindrical surfaces cast into as many saddle pads in the bottom of the lower housing. After these surfaces have been coined to the proper depth and alignment, the stator rests upon them by two lower alignment pins that provide four trunnion extensions from the core, *Fig.* 4. These steel pins have a relatively larger diameter and are cyanide hardened and centerless ground so they can be pressed through the punchings. Primarily they provide supporting surfaces having accurate dimensional relationship with respect to the stator bore, but they also take the place of holding rivets in the core laminations.

Eliminates Machining Operations

This method of housing support for the stator core provides good air-gap concentricity. It eliminates primary-core machining and slow multiple punch-press operations with compound dies when producing the rotor and stator laminations. Both laminations are obtained in a high-speed punch-press from coiled electrical strip steel in five stations of a progressive die. Consideration of die strength does not permit trimming the outside diameter and air gap in the same die station. When cut in different stations, the concentricity of these two diameters is subject to variations in indexing the strip, making the outside diameter unreliable as a housing seat unless it is ground concentric with the bore after riveting. The four alignment holes, however, can be punched at the air gap trimming station, so good accuracy in relative spacing of these five holes is assured.

Clamps Stator Rigidly

The upper housing clamps the stator firmly into its alignment position in the lower housing and, at the same time, exerts pressure on the two self-aligning rotor bearings. Holding fan guard and gear-case cover in their assembled positions in the lower housing eliminates use of separate fastening. The two housing halves clamp the stator rigidly, if a gap is allowed at the split line, because the upper housing half can center itself on the upper field alignment pins by riding the four trunnion extensions of the pins with its four pressure pads (*Fig.* 5).

Other parts are held by resilient pressure methods. In the case of the self-aligning bearings, this is accomplished by a leaf spring for each bearing. This spring, punched from tempered spring steel with a center hole for the spherical bearing, is designed to have its ends bear against the upper housing. The edge of the center hole gives the required pressure distribution to avoid distortion of the bearing. The upper housing is cast with a wall outlining each leaf spring, with clearance to permit a motion of 1/64-inch in any lateral direction. This allows the spring to center itself over the spherical bearing. These walls also provide the means of retaining the leaf springs in the upper housing.

Four thin retaining chips at each wall, made by sharp blades in a staking fixture that strikes 0.010-inch from the wall edge, prevent the springs from dropping out while handling the upper housing. A

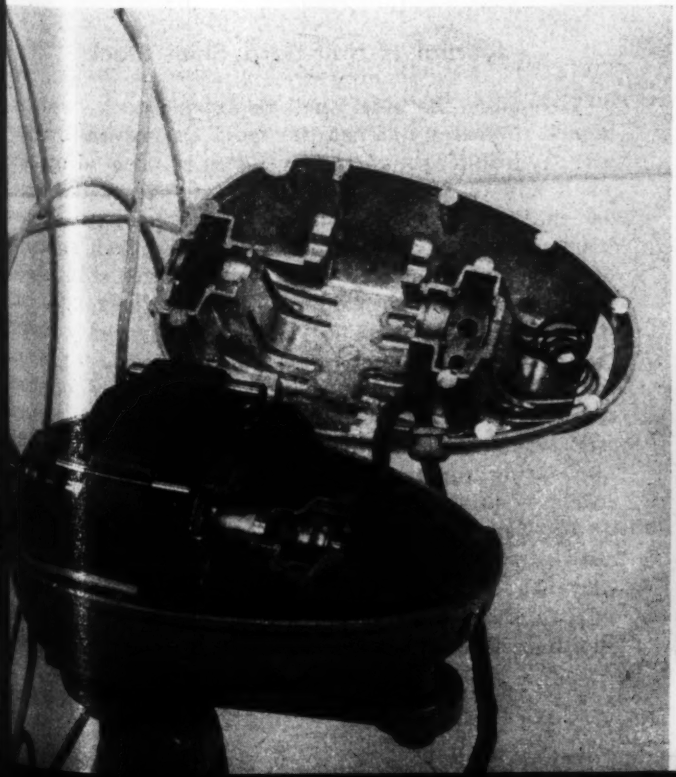
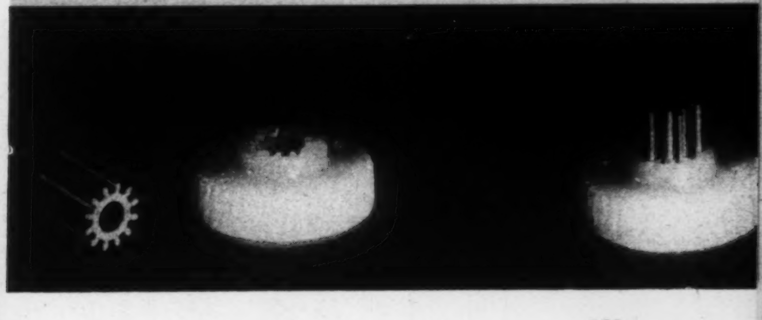


Fig. 5—One clamping action between housings serves to fasten stator, rotor bearings, guard, gear case cover and cable grommet

Fig. 6—Two-piece gear cluster combines advantages of plastic and sintered iron molding for economy, strength and quietness



high-silicon alloy is preferred for the upper housing to insure a reasonably permanent polish for the appearance stripes, but the iron content must be kept low to provide the necessary ductility for the chip-shaving operation.

The resilient pressure to hold the gear-case cover against its seat is provided by a helical spring with a friction-fit on a pin extension of the upper housing. The spring pressure on the guard is obtained by curving the upper guard support wires so the housings are forced to straighten the curve as they are drawn together by four self-tapping screws driven from cast clearance holes in the lower housing and into smaller cast holes in the upper housing. They are the only screws in the motor body, their heads being concealed in deep recesses.

The squirrel-cage rotor also received its share of attention in this labor-saving design. Pure aluminum windings of this size can be successfully die-cast in molds with as many as eight cavities. By punching the shaft hole and the rotor slots in the same station of the lamination die, good concentricity and inherent static balance are assured. Ventilating vanes are cast on the end rings with the object of providing a convenient means of balancing. However, it proved unnecessary to shear off any of the vanes to balance the rotor for its running speed of 1400 rpm. To eliminate the need of extra sleeves to serve as hubs or thrust collars, the rotor is designed so that hubs can be cast integral with the slots and end rings. The heat dissipation to the bearings is reduced to a normal rate by a bent spring-steel washer placed between two fabric phenolic thrust washers, *Fig.* 4. These serve the dual purpose of cushioning end-bump and of insulating the heat-flow path through the thrust washers.

Previously, the decision had been made to use spur gears for the second reduction in the oscillating mechanism to favor the housing design cost-wise. Spur gears also offer cost advantages over helical or worm gears when obtained by mass-production methods. To insure minimum noise, the first-reduction worm gear is nonmetallic. By using a multicavity mold, this gear is produced from a high-strength thermoplastic at minimum cost. The cold-flow properties of the plastic make it possible to consider spur gear teeth to mesh with the steel worm of low helix angle so that the outer gear teeth and the spline fit for the second reduction pinion can both be parallel to the direction of mold separation. The concentric spline is a light push fit over the sintered iron-powder pinion which, in turn, is produced with the journal bore for the gear cluster molded and sized to accurate dimensions, *Fig.* 6.

The gear case cover and the shoulder of the first reduction stud prevent axial separation of the two parts. Extensive development showed sintered iron to be a natural choice for the second reduction spur gear. A square center hole simplifies the problem of fastening the gear to the shaft with a good driving fit.

Zinc diecasting alloy is satisfactory as a material for the entire crankshaft assembly in every respect except one. It is unsuited as a journal material because of rapid wear under the prevailing conditions of imperfect lubrication. But if the shaft is given a shell of strong, hard, wear-resistant material, it is possible to cast the entire assembly, including the square gear fit on the shaft and the throw adjusting slot in the crank, without machining or assembly operations.

Journal Is Half-Hard Shim Stock

To enable the steel shell to expand to a predetermined diameter against the mold cavity walls under the hydraulic pressure of the fluid zinc alloy, the shell has an open longitudinal joint. Then, the edges of the joint are flanged inward to provide a good anchor in the body of the shaft. The shell material is 0.005-inch thick half-hard polished-steel shim stock. It is formed in a progressive die and then forced into the mold cavity before diecasting. Natural outward springing of the shell seals off the fluid zinc at the longitudinal joint, and the casting pressure of more than 5000 psi forces the thin shell outward against the cavity walls. This provides the zinc shaft with a wearing surface which is smooth, strong, and accurately sized.

The following conventional operations are eliminated: Forming and cutting the steel shaft, milling the flats for the square gear fit, grinding the body of the shaft, and assembling the crank to the shaft. The normal diecasting and trimming operations for a die-

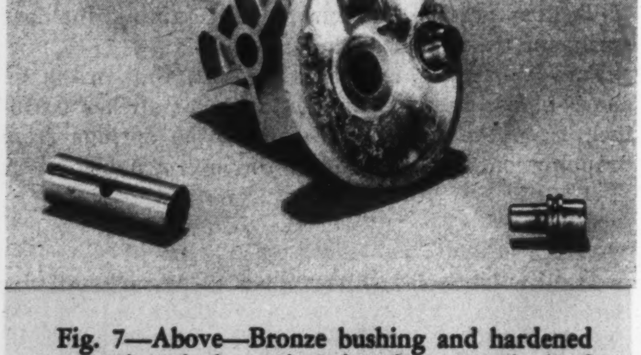


Fig. 7—Above—Bronze bushing and hardened wristpin of the swivel housing are obtained without added cost

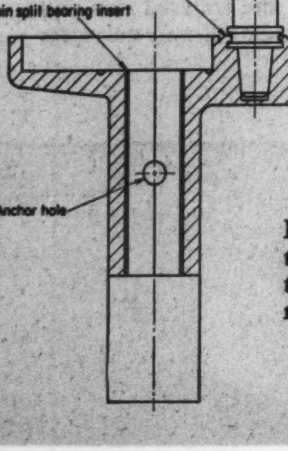


Fig. 8—Left—Staking tool rolls bead from top of hole into pin retaining groove of wristpin

cast crank serve for the entire assembly, and a ten-cavity mold reduces the diecasting labor per piece to a minimum.

A conventional swivel housing has a vertical swivel bearing which is merely a reamed hole in the zinc die-cast body. The connecting-rod wristpin usually is made of unhardened screw machine steel riveted or bolted in place. How can a better wearing surface for both points be provided at reduced cost? Wristpins extend only a short distance from the swivel housing. That makes it impractical to consider them as inserts in diecasting because of inadequate support in the die before the metal fills the mold. Mechanical means of fastening usually require a reaming operation for the pin hole to insure a tight fit and preclude the use of a hardened pin. In this case, a hole is cast in the swivel housing with a taper of ⅞-inch per foot and with an enlarged cylindrical extension around the pin, ***Fig.*** 7. The pin is designed with a tapered shank to give a press fit in the die-cast hole under all tolerance conditions. Also, it is provided with an adequate shoulder to form a firm seat on the diecasting, a retaining groove, and a second shoulder and cylindrical fit for the connecting rod.

Bearing Is Finished By Burnishing

These five functional surfaces are all turned from bar stock in a screw machine. Best practice requires that the cylindrical connecting-rod bearing be given a finish before cyanide hardening to prevent rapid wear of the rod. To avoid costly grinding operations, this can be done in a standard thread-rolling machine by substituting hardened and polished blocks for the usual knurling or threading tools. This operation not only rolls down the machining tool marks but also reduces the diameter tolerance and corrects much out-of-roundness. The fixture that presses the pin into its fit in the swivel housing follows with a staking tool, rolling a bead of zinc alloy from the top of the cylindrical hole extension into the pin retaining groove, ***Fig.*** 8. This gives the hardened wristpin a secure fastening in the diecasting without any separate machining operations for the fit.

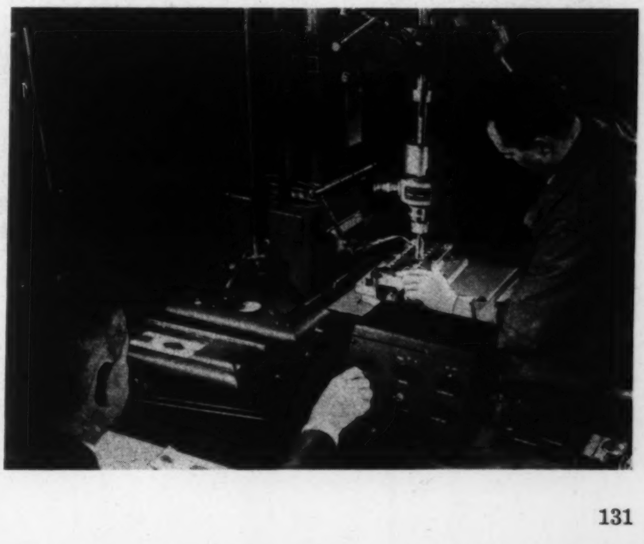
Lessons learned in developing the crankshaft can be applied to the swivel housing to provide it with a bearing liner without added cost. By forming the bearing-liner shell of thin bronze with a tight longitudinal joint, an internal diameter several mils smaller than the final bore diameter can be used. The cylindrical pin in the die-cast mold, upon which the bronze shell is forced as an insert, has a diameter the same as the final bore plus a shrinkage allowance. When the die-cast metal is forced into the mold cavity under pressure, the thin bearing liner is forced into still more intimate contact with the die pin so that a bore-sizing operation results. The cost-saving over the customary bore-reaming operation pays for the liner and its application. A hole is punched through the wall to anchor the thin liner tightly in the die-cast metal so that it does not loosen at the joint, ***Fig.*** 8. This hole permits the zinc alloy to enter against the die pin to provide an anchoring button. The alloy button enters at a point where the diameter of the swivel pin is reduced for lubricant retention so that only bronze contacts the swivel pin at its cylindrical bearing fits.

Accelerated tests of mechanical parts and a life test of thirty complete fans from the original sample production run prove the success of the novel constructional details. Experience in producing and marketing the fans has proved the soundness of the manufacturing and cost concepts.

Instrument Records Tapping Torques

NOVEL method of producing continuous records of the torque throughout thousands of tapping operations during a two-year tap-torque testing program has given Greenfield Tap and Die Corp. accurate histories of tapping cycles. These records are the basis for the design and production of taps, as well as recommendations for most efficient tapping operations. To measure the effort required to turn the tap, the vertical drive shaft incorporates a Baldwin SR-4 Torquemeter. This instrument is completely independent of tapping operations, absorbing negligible power and thus permitting 99 per cent accuracy under shop operating conditions. Rapidly varying torque is recorded by a high-speed, ink writing oscillograph on a paper strip chart.

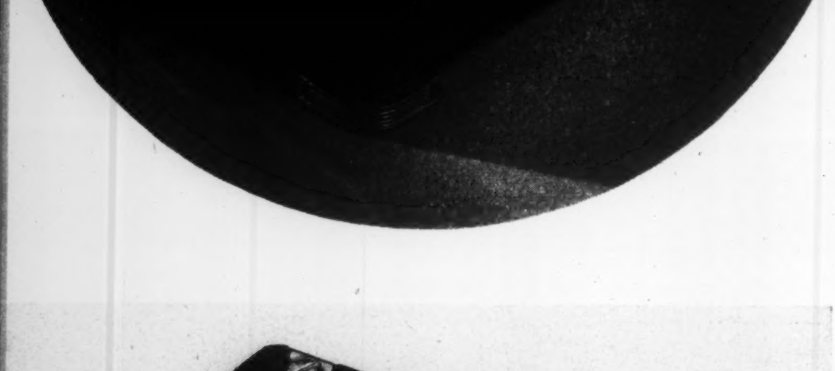
The torquemeter is essentially a short length of shaft to which a group of special SR-4 resistance-wire strain gages are bonded to form a Wheatstone bridge. The corners of the bridge are connected through slip rings on the shaft to stationary brushes in the case and from thence to the recording oscillograph. By means of this equipment, it has been possible to determine the effects of rake or hook, relief, chamfer, and other factors, as well as operating conditions such as speed, lubrication and wear rate.

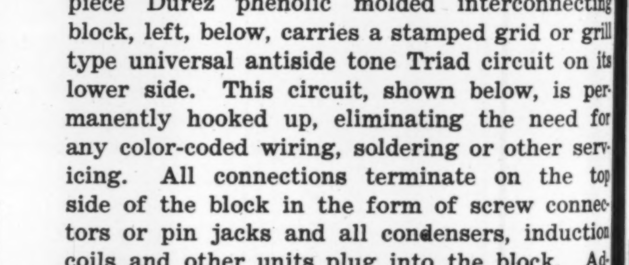


Contemporar

Stamped Circuit Simplifies Telephone

COMPLICATED wiring and color coding previously found in telephone bases are eliminated in the new Masterphones, left, made by Kellogg Switchboard and Supply Co. A one-piece Durez phenolic molded interconnecting block, left, below, carries a stamped grid or grill type universal antiside tone Triad circuit on its lower side. This circuit, shown below, is permanently hooked up, eliminating the need for any color-coded wiring, soldering or other servicing. All connections terminate on the top side of the block in the form of screw connectors or pin jacks and all condensers, induction coils and other units plug into the block. Adjustments and servicing of the phone require only a screw driver. A standardized metal base plate is used in both desk and wall models, conversion from one model to the other requiring only a change in the plastic housings.

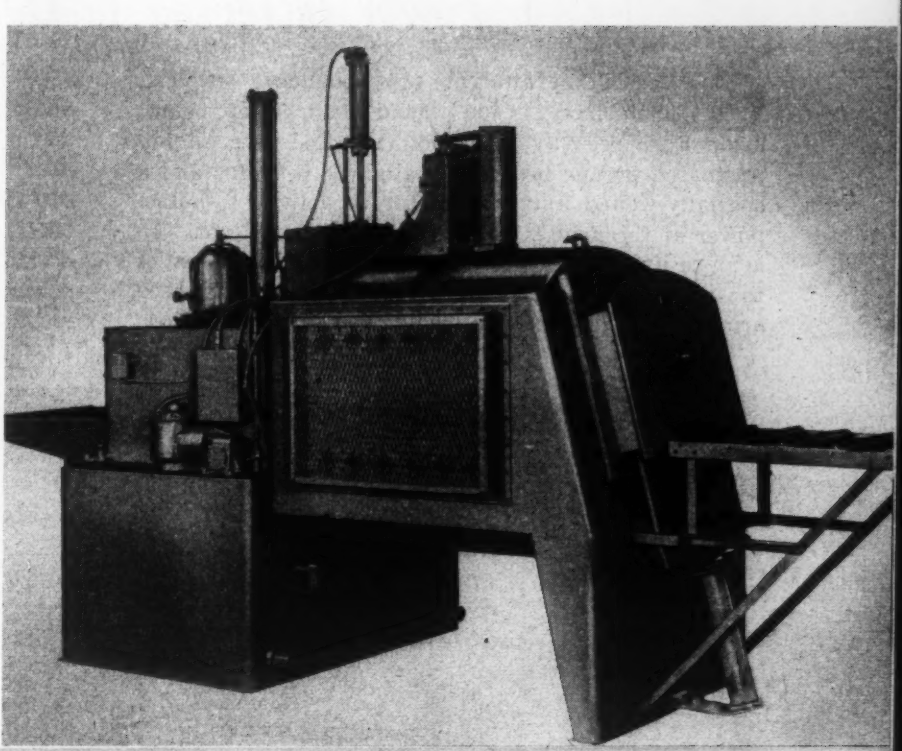


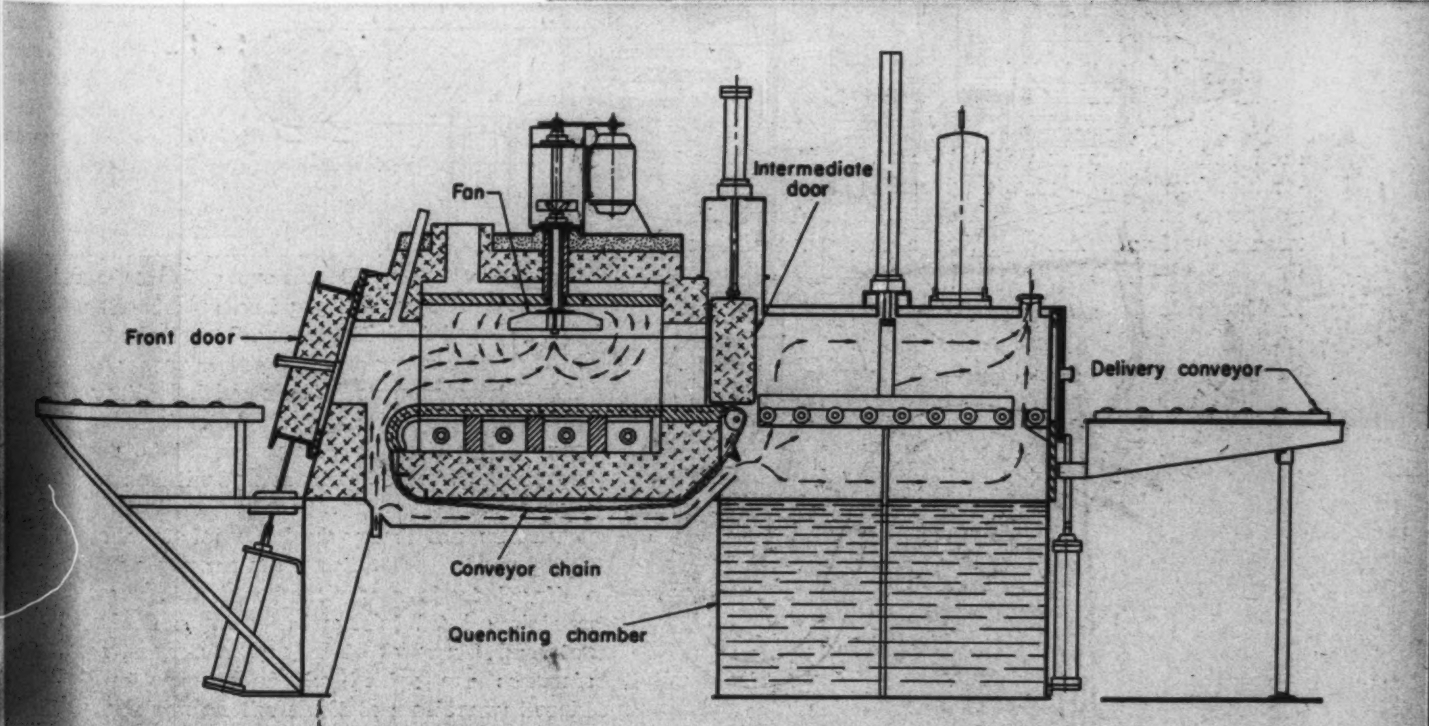


ESIGN

Heat Treater Incorporates Automatic Cycling

A FULLY automatic universal heat treating unit, right, the T-250-E made by Ipsen Industries Inc., combines a furnace and cooling or quenching chamber with automatic work handling. The sealed, atmosphere-controlled 1750 F maximum-temperature furnace, shown in the drawing, below, is separated from the cooling compartment and 400-gallon quench tank by a hydraulically controlled intermediate door. After a trayfull of parts is loaded in the gas-fired furnace, a timer is set for the heating cycle and another control ad-



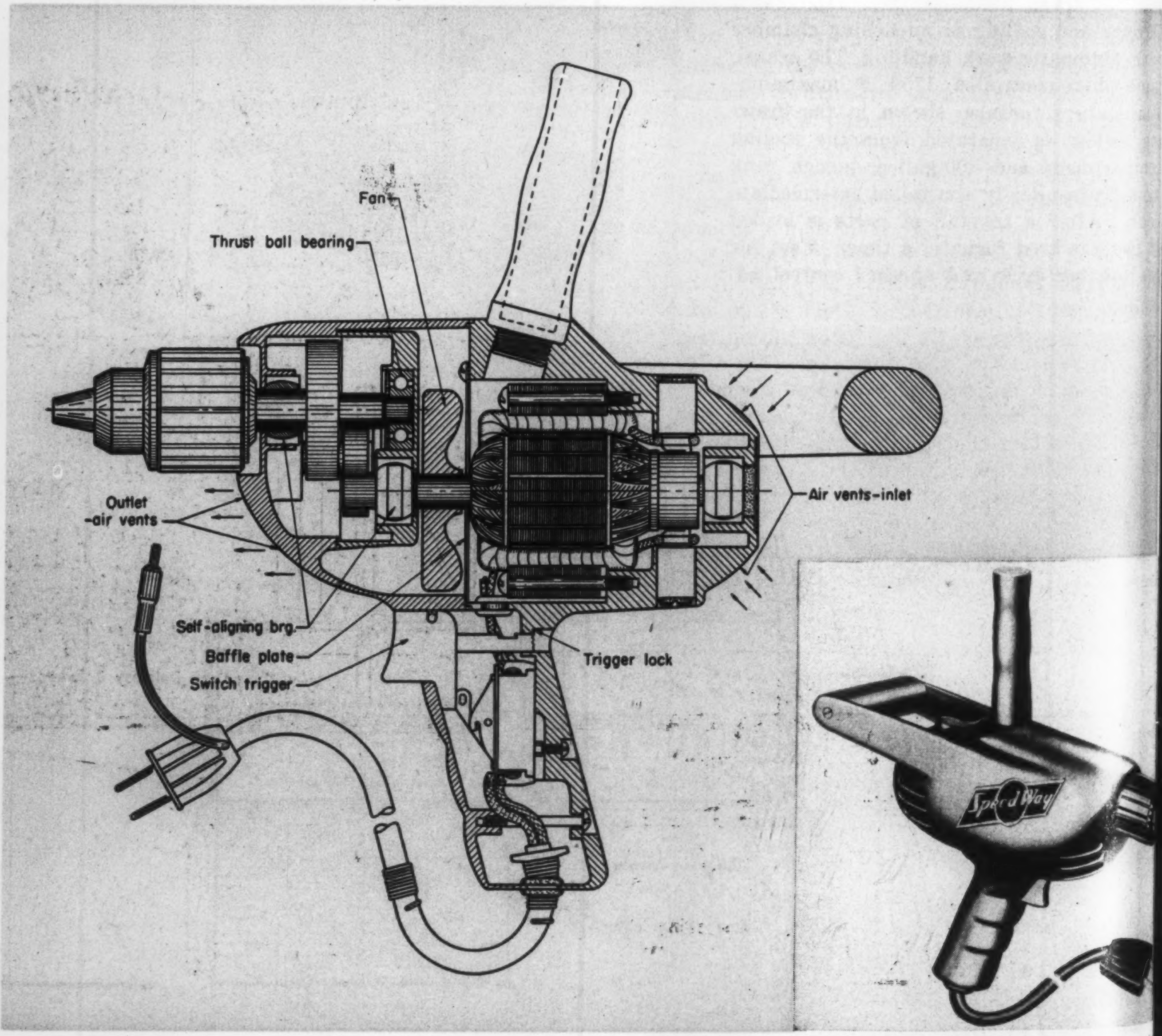

Fan
Intermediate door
Front door
Delivery conveyor
Conveyor chain
Quenching chamber

justed for oil quenching or air cooling time. When the heating part of the cycle is completed, the work automatically passes into the right-hand chamber, shown in the drawing, and a signal light indicates that the furnace is ready for another load. On completion of quenching or cooling, another light signals that the work is ready for removal. The three doors and the work-handling elevator in the quench tank are hydraulically actuated. A maximum of 250 pounds of parts per hour can be handled in the unit.

Contemporary DESIGN

Power Increased in Lightweight Drill

COMPACT, lightweight (8¾ pounds), low-cost, ½-inch model "400" hand drill, inset below, made by SpeedWay Manufacturing Co., uses oil impregnated porous bronze self-aligning bearings and a specially-wound universal motor to deliver ½-horsepower at the drill at an efficiency of 48 per cent. To achieve light weight and adequate power, diameter of the motor was kept small, necessitating a high-speed armature. The large fan employed, drawing below, acts as a brake for the motor when running idle and also draws a large amount of air over the motor and around the sealed gearbox, another source of heat. The motor draws 5¼ amp, drives the drill at 600 rpm no-load speed and 450 rpm at 50 inch-pounds load. The alloy steel gears are all mounted on individual shafts, with each shaft supported on two spaced bearings, and the complete gear case is removable as a unit for servicing.



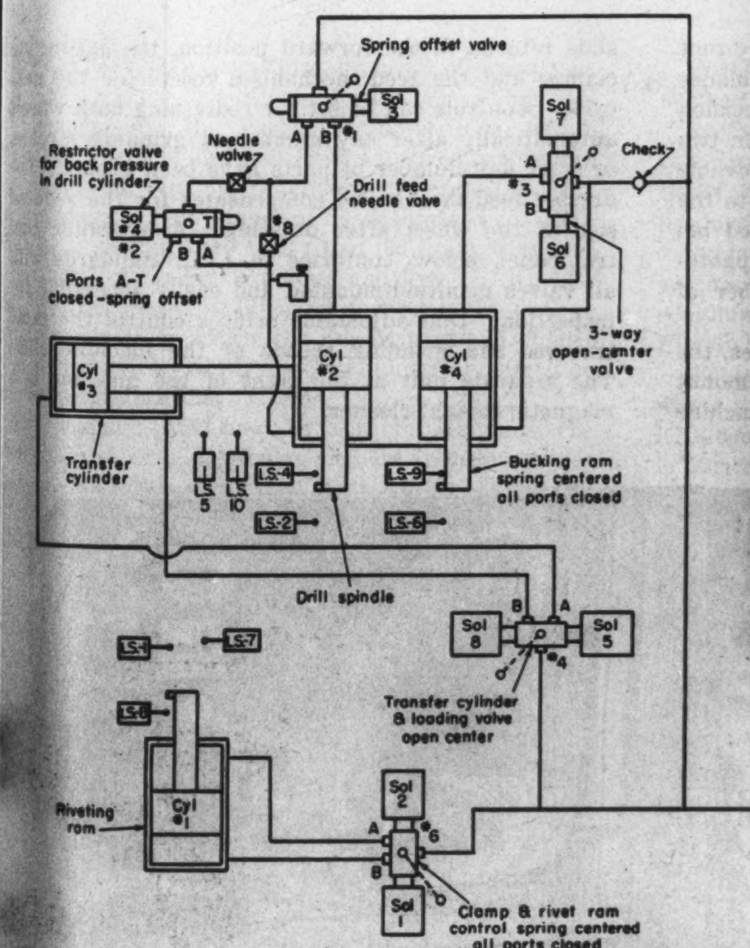
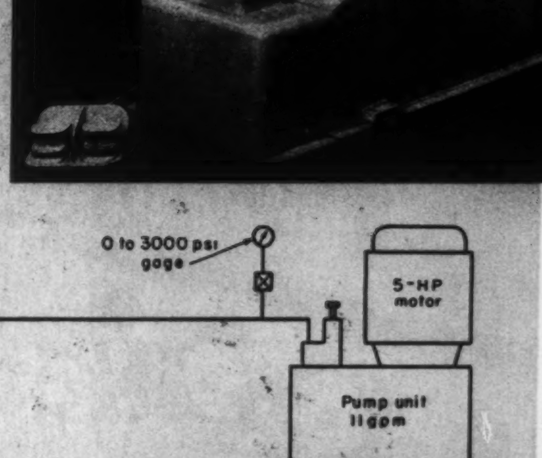
Riveter Features Four-Second Cycle Time

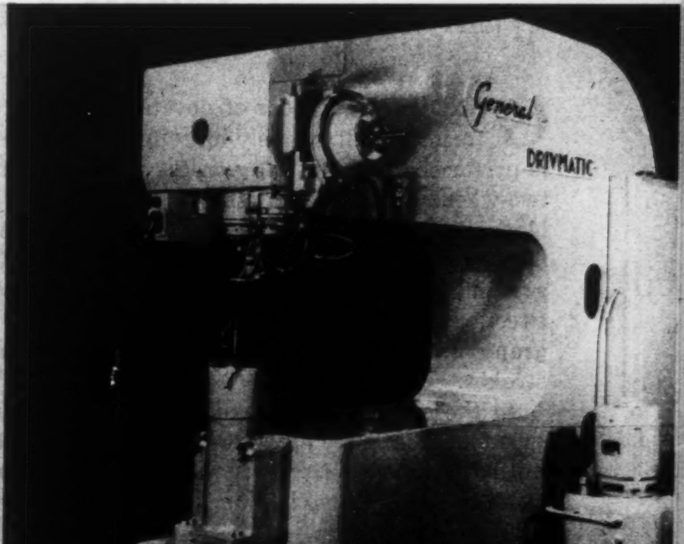
A MACHINE which clamps, drills and countersinks a workpiece, then inserts and heads a rivet—all in one continuous automatic cycle—is shown below, right. The new Drivmatic model G-39A made by General Riveters Inc. is designed to handle flat or contoured surface work such as wing skin and stringer assemblies, wing and fuselage bulkheads, and spars. It incorporates two hydraulically operated spindles, one for drilling and one for riveting, which alternate back and forth over the lower anvil.

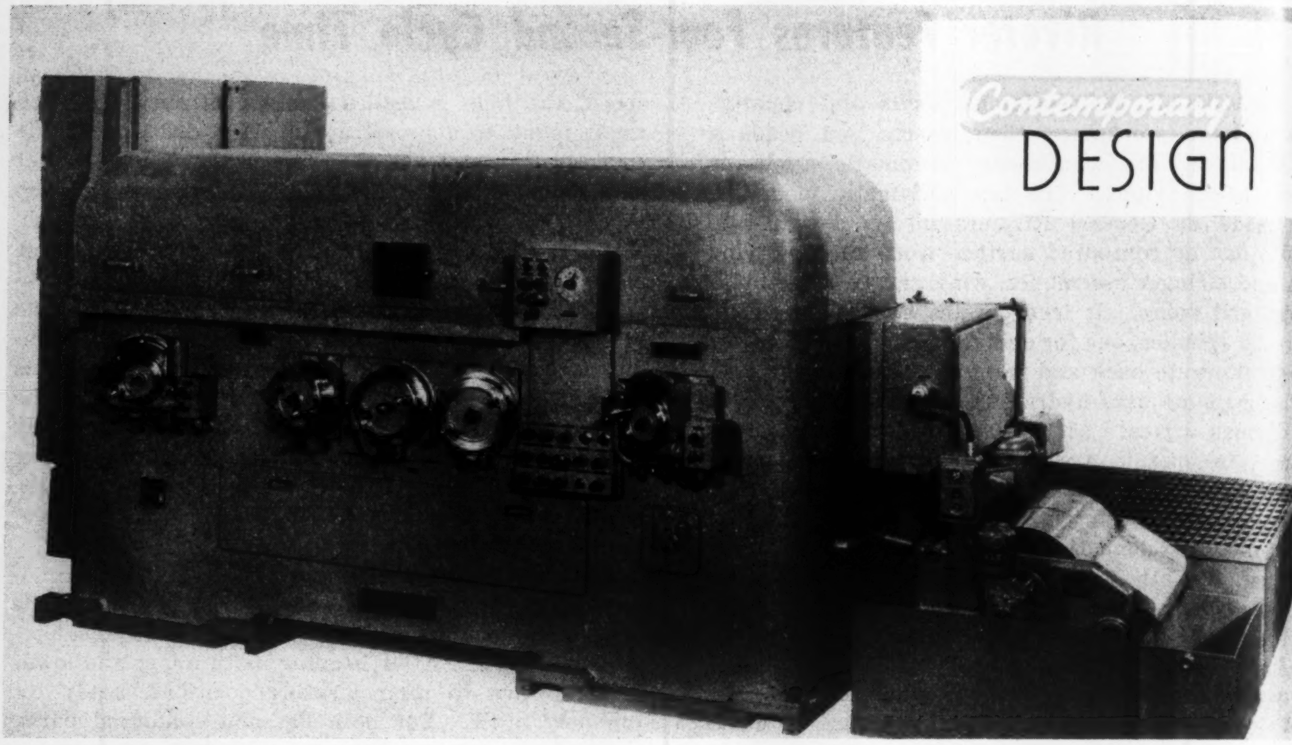
The machine uses hydraulics, air and electricity in its various drives. Air is used to actuate the rivet hopper, to operate a positive rivet injecting mechanism and to blow chips. The functions of clamping, drilling, rivet inserting, bucking and riveting are done hydraulically, schematic circuit diagram, below, to obtain rapid controlled movement of heavy clamping and riveting members.

In operation, when the foot switch is depressed the lower anvil rises until the pressure sleeve clamps the work firmly against the upper stationary pressure foot. This preadjusted clamping pressure is maintained continuously throughout the complete cycle. Then the drill spindle approaches the work at high speed, the hole is drilled under controlled feed and countersunk to a preset depth. The drilling cycle is controlled by restriction of the oil flow on the outlet side of the drill spindle cylinder during drilling so that there is a cushion to prevent break through. When the drilling ram reaches a positive, adjustable stop, pressure at the outlet drops, operating a pressure switch which initiated the drill return. While the drill spindle approaches the work, the rivet feed mechanism drops a rivet into an injector which positions it in the feed fingers. As the drill point clears the pressure foot, the bucking anvil and the previously loaded rivet finger move into position directly over the drilled hole. The bucking anvil then descends, contacts the rivet and carries it through the rivet fingers into the hole.

After the rivet is inserted, the bucking anvil cylinder is hydraulically locked off for bucking. The lower ram is reactuated to head the rivet to a preselected height. After heading, both upper and lower heads return to their starting positions, ready for the next cycle. For both flat and contoured parts, cycle time (less positioning) is 3.5 to 4.5 seconds on most types of work.



Spring offset valve
Sol 3
A
B
#1
Needle valve
Restrictor valve for back pressure in drill cylinder
Sol #4
#2
O T
B A
Ports A-T closed-spring offset
Drill feed needle valve
#8
Sol 7
A
#3
B
Sol 6
Check
3-way open-center valve
Cyl #3
Transfer cylinder
Cyl #2
Cyl #4
LS-5
LS-10
LS-4
LS-9
LS-2
LS-6
Bucking ram spring centered all ports closed
Drill spindle
B
A
Sol 8
Sol 5
#4
Transfer cylinder & loading valve open center
LS-1
LS-7
LS-8
Riveting ram
Cyl #1
Sol 2
A
#6
B
Sol 1
Clamp & rivet ram control spring centered all ports closed
0 to 3000 psi gage
5-HP motor
Pump unit 11 gpm

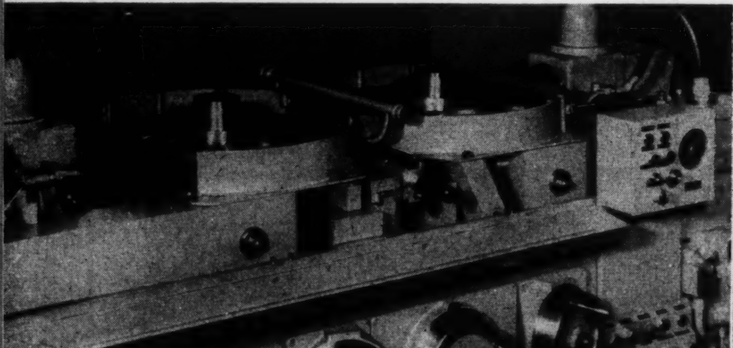

General
DRIVMATIC

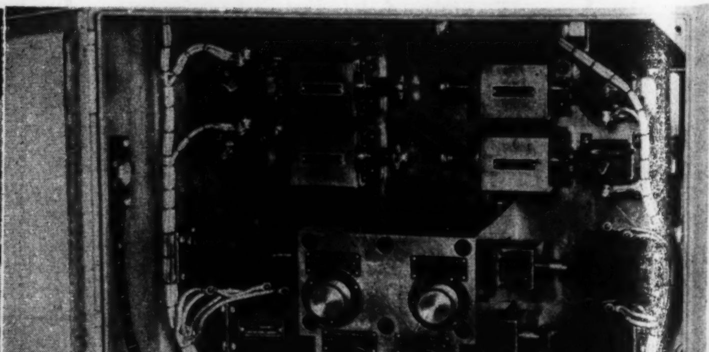


Grinder Finishes Jet Blade Roots

GRINDING both sides of dovetail or pine-tree root forms simultaneously on tough jet engine blades is performed automatically on the Ex-Cell-O precision two-wheel form grinder shown above. One or two blades, depending on size, are held in a removable fixture on the machine slide. Parts are moved to the grinding wheels and reciprocated at a set speed between two 24-inch diamond-dressed wheels, photograph at the left, below, for a selected number of strokes.

At the end of each stroke, or alternate strokes, the grinding wheels feed toward the work a preset amount until the finished size is reached. Then the machine slide returns to the forward position, the fixture unclamps and the feed mechanism resets for the next cycle. Controls can be set for redressing both wheels automatically after any number of grinding strokes, or after any number of parts have been ground. The dresser feed mechanism compensates for the reduced size of the wheel after dressing. A hydraulic control panel, below, conforms to J.I.C. standards with all valves manifold-mounted and easily accessible for inspection. Dial adjustable orifices control the rapid traverse and grinding speeds of the machine slide. The separate unit at the right of the machine is a magnetic coolant cleaner.





Surface Finish Standards

. . . for roughness, waviness and lay, as adopted by the Department of Defense

By T. E. Cassey
Head Engineer
Electrical Distribution Branch

and

J. W. Sawyer
Turbine and Gear Branch

Bureau of Ships, Department of the Navy

TO PROVIDE a uniform practice of specifying the surface conditions desired on a machine component, the various organizations within he Department of Defense have approved a standard or specifying surface roughness, waviness and lay n drawings. This standard is designated as MIL-STD-10, 2 August 1949, and titled "Military Standard —Surface Roughness, Waviness and Lay." Although se of this standard is mandatory only in dealing ith organizations within the Department of Defense, t should prove to be of value to industrial as well as ilitary organizations.

The designer will now be able to designate the urface finish on a particular element in such manner hat an inspector or a machinist can easily undertand the results desired. Surfaces specified by the ractices outlined can be measured by several types of nstruments now in wide use throughout industry, nd the method by which a surface is produced or easured does not limit use of the standard. To acuaint engineers and designers with the standard, his article briefly summarizes its major points.

Definition of terms used is most important for a horough understanding of the methods specified. The ollowing terms are used in the standard:

Surface: The surfaces of an object are the limitng boundaries of the object.

Mean surface: This is the imaginary surface which ould be obtained if all the peaks, ridges and hollows f a surface were averaged to a zero value. This ondition would be reached when the odd-numbered nd even-numbered areas of *Fig.* 1 were equal.

Profile: The contour of any specified section of a surface such as that designated in *Fig.* 1.

Surface roughness: Deviations of the actual surface from the mean surface in the form of relatively finely spaced surface irregularities, such as those produced by cutting tools and abrasive wheels.

Surface roughness width: The distance between successive peaks or ridges which comprise the surface roughness pattern. Roughness width is designated in *Fig.* 2.

Waviness: Surface irregularities in the form of waves which are of greater spacing than the irregularities constituting surface roughness. Waviness height is illustrated in *Fig.* 2.

Lay: The direction of predominant surface patterns found on surfaces is termed lay. The lay of a surface, shown in *Fig.* 2, may be produced by the action of cutting tools, abrasives such as used in lapping, or by forming dies.

Flaws: Irregularities in profile at relatively infrequent intervals are designated as flaws. They include checks, cracks, blow-holes, chatter marks and scratches.

Root-mean-square rms: The term rms is used in connection with a surface roughness value or number and indicates that the value is assumed to be approximately equal to the square root of the mean value of the squares of the heights and depths of the surface roughness irregularities measured from the mean surface in micro-inches. The root-mean-square value may be expressed as

$$rms = \sqrt{\frac{A^2 + B^2 + C^2 + D^2 + E^2 \ldots}{N}}$$

where $A, B, C, D, E, \ldots$ represent in microinches the deviations of the profile from the mean surface measured at uniform intervals along a profile in a direction that gives the maximum value and N is the number of measurements. Measurements of a profile, as shown is *Fig.* 3, illustrate actual values of each increment and the rms value obtained. The rms values specified on drawings and in specifications should be values corresponding to surface roughness measured with direct reading stylus type instruments such as the Profilometer or Brush Analyzer.

Surface roughness number: The roughness of a surface is a physical value expressed in microinches rms. A series of approved values of surface roughness numbers is as follows: ¼, ½, 1, 2, 4, 8, 16, 32, 63, 125, 250, 500, 1000, 2000. Other values may be specified for particular cases that are not met by the numbers. The selection of numerical values and the application of the particlar values to components are matters for the design in question and the design practices of the manufacturer.

METHOD FOR SPECIFYING SURFACE ROUGHNESS: The symbol used to embrace the surface roughness number, which represents the maximum acceptable roughness or two numbers which set the maximum and minimum acceptable values, is shown in *Fig.* 4. Dimensions of the symbol are approximately as shown; however, they may be varied to suit the needs of any drawing. The general practice is to place the apex of the symbol touching the surface under consideration, as shown in *Fig.* 5. If space is limited, the apex may be placed on an extension line or an arrow, as shown, *Fig.* 5. The surface roughness should be shown in one place only and should not be duplicated.

Parts that are to be finished all over to a uniform surface roughness are so specified by a note, with the degree of roughness designated in the note. Other finish marks or symbols should not be used on the drawing. Where parts are to be finished all over but to different degrees, a note on the drawing should be used to designate the exception, as illustrated in *Fig.* 6. Where there is no predominant surface roughness, individual symbols should be used with the desired roughness number for each area under consideration and the note

“ xx√ all over except as noted”

should be omitted. Whether the roughness numbers should be oriented to be read from the bottom or the right depends, of course, upon the drafting convention employed for other dimensions.

Methods used to specify surface roughness on drawings for castings, forgings and plated surfaces are:

Castings and Forgings: Where all finished surfaces require the same degree of roughness, a note on the drawing should be used. The surfaces to be finishe should be designated with blank surface roughne symbols. Surfaces to have varying degrees of rou ness should be properly marked as in *Fig.* 7.

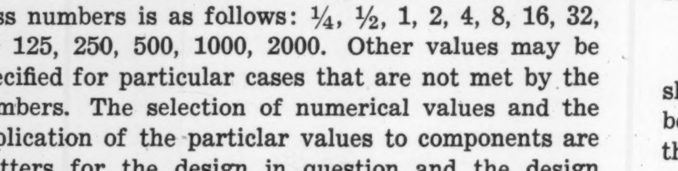


Fig. 1—Above—Mean surface is so located that odd-numbered areas are equal to even-numbered areas

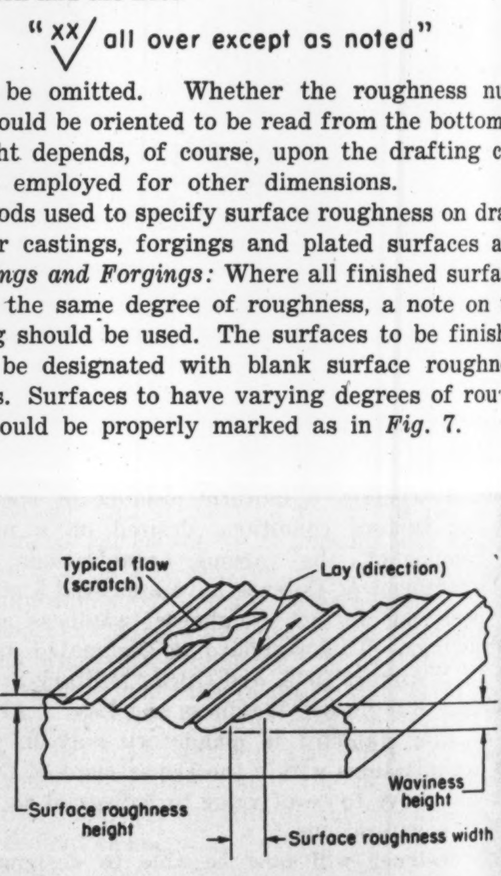


Fig. 2—Above—Surface features include roughness height, waviness height, roughness width and lay (direction of pattern)

Fig. 3—Below—Example of surface roughness profile shows method of determining rms value of surface profile

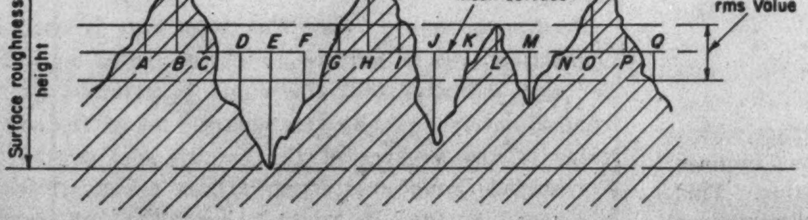
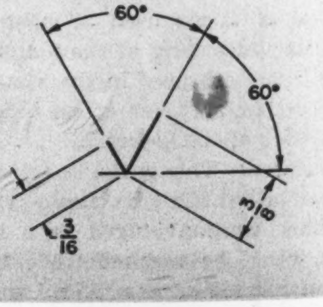


Fig. 4—Below—Symbol used to indicate surface roughness



Plated Surfaces: The methods for specifying surface roughness on plated areas are similar to those described in the preceding paragraphs. However a note should be added to indicate whether the roughness specification is to apply before or after plating.

Surfaces that are to be prepared by special operations, such as buffing, lapping, scraping, honing or blasting, should have the roughness specified by the surface roughness symbol and number followed by a notation stating the required operation.

Surface roughness should not be specified on drawings for parts where the surface produced by first-class workmenship is considered to be satisfactory. However, when the surfaces of such parts are critical for proper operation, an appropriate surface roughness number should be designated regardless of whether the number so specified is the same as the number in a note on the drawing. Normally a surface roughness number is not required for:

- 60-degree screw threads
- Pipe threads
- Tapped holes
- Drilled holes
- Reamed holes
- Countersunk holes
- Ends of bolts, studs
- Keyways of minor importance
- Cast surfaces
- Rolled surfaces
- Extruded surfaces
- Splines in holes
- Splines on shafts
- Broached holes
- Machine screw holes
- Counterbored holes
- Tool runout (thread relief)
- Screw driver slots
- Bolt and screw heads
- Spot-faced surfaces
- Sheared surfaces
- Sand, shot or hydroblasted surfaces

METHODS FOR SPECIFYING WAVINESS AND LAY: Waviness, *Fig.* 2, is of importance on surfaces such as bearings, journals, and areas where it is essential to control the percentage of contact. If control of waviness is necessary, the value of waviness height should be noted on the drawing as the maximum permissible depth from crest to valley in decimal parts of an inch. Inch values should be selected from the following series:

0.00005
0.00008
0.0001
0.0002
0.0003
0.0005
0.0008
0.001
0.002
0.003
0.005
0.008
0.010
0.015
0.020

In addition to waviness height, the required contact or bearing area should be specified as a percentage of the total area. The contact area should be uniformly distributed over the surfaces under consideration unless specifications to the contrary are noted on the drawing.

Waviness height may be measured by suitable dial indicators. Contact areas may be determined with bluing; a visual estimate is generally satisfactory in establishing the contact in per cent.

Lay, which is the direction of the predominant surface roughness pattern as illustrated in *Fig.* 2, may be of primary concern on machined surfaces of journals, bearings, cylinder walls and piston rods. It should be specified by notes on the drawing such as: "Lay perpendicular to long axis" or "lay multidirectional". If the number of notes regarding specifications for lay are such that a drawing would become difficult to read, then symbols listed in the following paragraph may be used in conjunction with the symbol of *Fig.* 4. Lay directional symbols for use with surface roughness symbols have been selected as follows:

Symbol	Description
=	Lay is parallel to the boundary line representing the surface to which the roughness symbol applies. The numerical value of the width of the roughness spacing is added to the right of the directional symbol such as = 0.008. This applies to all directional symbols.
⊥	Lay is perpendicular to the boundary line representing the surface to which the symbol applies.
×	Lay is angular in both directions to the boundary line representing the surface to which the symbol applies.
M	Lay is multidirectional.
C	Lay is approximately circular relative to the center of the surface marked with the roughness symbol.
R	Lay is approximately radial relative to the center of the surface indicated by the symbol.

SYMBOLS AND THEIR USE: Use of symbols for roughness and lay with roughness and waviness values is straightforward and will greatly simplify the problem of getting the desired information on drawings. Examples illustrating various combinations of roughness, waviness and lay specifications are shown in *Fig.* 8 and described as follows:

In *Fig. 8a* the surface roughness height, in microinches rms, is placed adjacent to and on the inside of the long leg. This is standard practice and should be observed in all cases.

When waviness height is to be specified the value, in inches, is placed above the horizontal extension line as shown in *Fig. 8b*.

Designation of lay is illustrated in *Fig. 8c* where the lay symbol is placed under the extension to the right of the long extension line of the surface roughness symbol as shown.

Fig. 8d illustrates the proper placement of roughness width values, in inches, when required. This

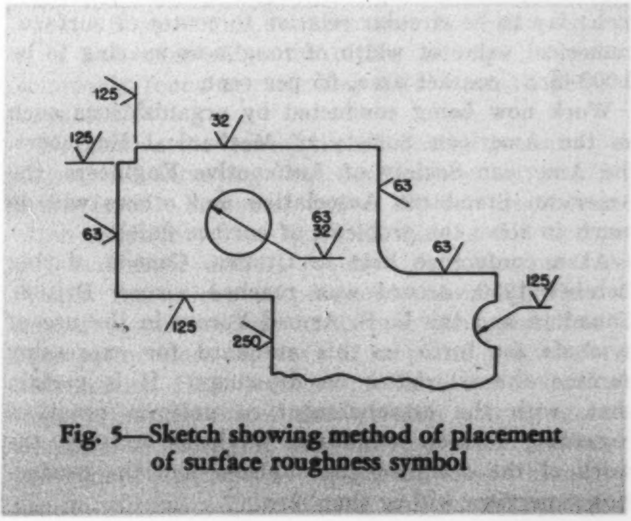


Fig. 5—Sketch showing method of placement of surface roughness symbol

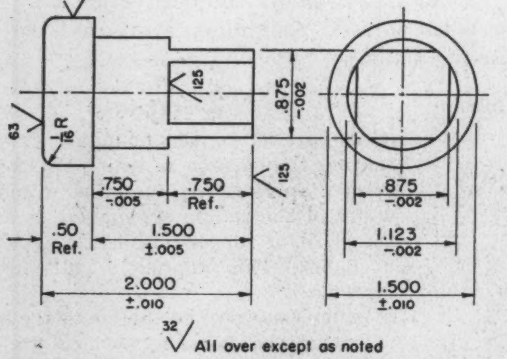


Fig. 6—Above—Drawing showing method of designating parts to be finished all over, but to a different degree on various surfaces

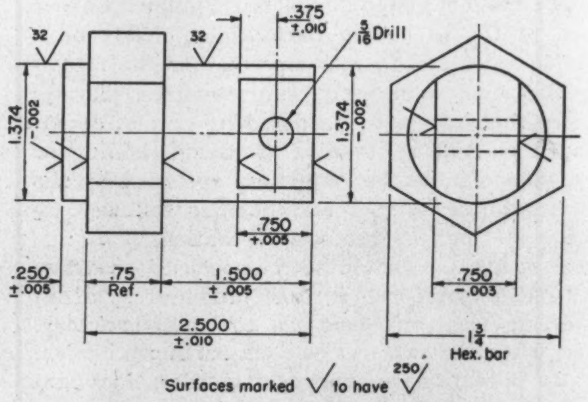


Fig. 7—Above—Marking of drawings for castings and forgings where only certain surfaces are to be finished to varying degrees

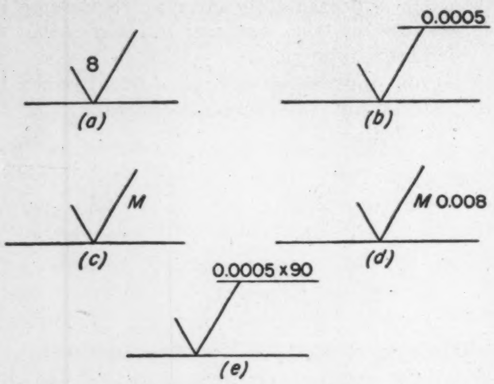
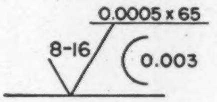


Fig. 8—Left—Symbols showing combinations of roughness, waviness, lay and contact area as a percentage of total area

Fig. 9—Right—Example of composite symbol for specifying roughness range, waviness, lay, roughness spacing and contact area in per cent



value is placed to the right of the lay symbol.

The percentage of contact area is placed above the horizontal extension line and to the right of the waviness value as in *Fig. 8e*.

The problem of specifying on a drawing the data necessary to give a complete story of the requirements of roughness, waviness, lay and contact area is shown by the following example and *Fig. 9*: A surface on a machine part is to have the following characteristics. Roughness within the range 8-16 microinches rms; waviness height maximum, 0.0005-inch; lay to be circular relative to center of surface; numerical value of width of roughness spacing to be 0.003-inch; contact area, 65 per cent.

Work now being conducted by organizations such as the American Society of Mechanical Engineers, the American Society of Automotive Engineers, the American Standards Association and others will do much to solve the problems of surface finish.

At a conference held in Ottawa, Canada, during October 1950, accord was reached among British, Canadian and the U. S. Armed Forces in the use of symbols set forth in this standard for expressing surface characteristics on drawings. It is certain that, with the establishment of uniform practices regarding surface roughness, waviness and lay, the work of the designer, the engineer and the production supervisor will be simplified.

Individuals and organizations interested in this standard may obtain copies by directing requests, which should contain the title and the identifying symbol number of the standard (Military Standard—Surface Roughness Waviness and Lay, MIL-STD-10, 2 August 1949), to one of the following agencies:

Department of the Army contractors, to the Contracting Officer.

Department of the Army agencies, to the Office, Chief of Ordnance, Washington 25, D. C.

Department of the Navy activities, to the Supply Officer in Command, Naval Supply Center, Norfolk 11, Va.

Department of the Navy contractors, to Bureau of Supplies and Accounts, Washington 25, D. C.

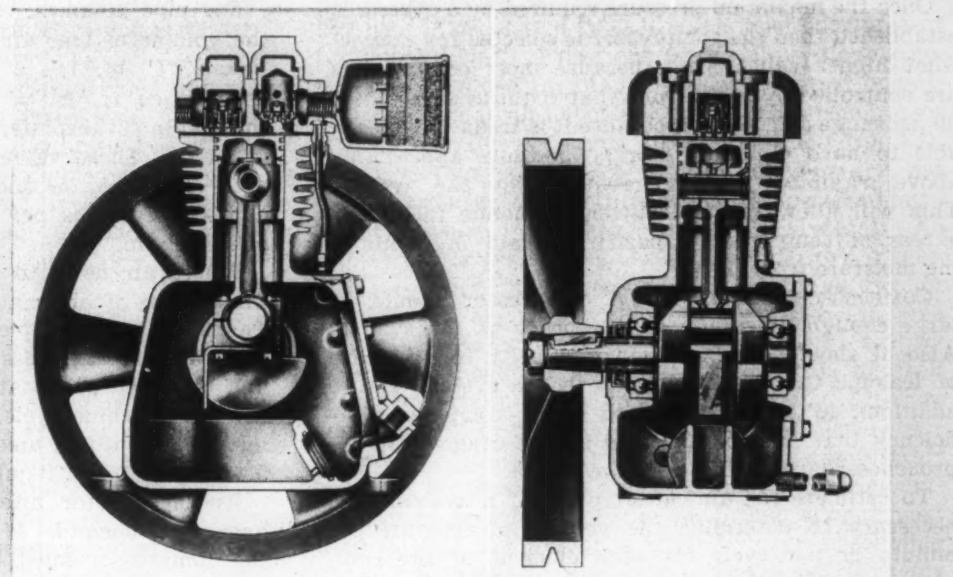
For the Marine Corps, to the Quartermaster General, Headquarters, U. S. Marine Corps, Washington 25, D. C.

For Department of the Air Force activities and Air Force contractors, to the Commanding General, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio.

Others, the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

Acknowledgment: The authors wish to express their appreciation to the Department of Defense for permission to publish this article.

Fig. 12—A typical single-stage air compressor



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Pneumatic Power

Design and application fundamentals for machine drives and controls

Part 2—Design of Air Supply Systems

SELECTION of compressors and design of air supply systems seldom receive attention commensurate with their importance; yet a pneumatic system is no more reliable than its air supply. The dryness and freedom from foreign matter of this supply determines the service life of most pneumatic devices in the system. A suitable compressor, *Fig.* 12, with adequately designed supply system is a primary requirement for any successful pneumatic system.

SELECTION OF PRESSURE: Minimum air pressure is usually dictated by the design application. In general, pressures ranging from 80 to 125 psi are most commonly used and probably represent the widest practical utility. In this range there are more varieties of compressors and pneumatic devices available to incorporate in design. Standard pipe, fittings, and hose are adequate for these pressures, and frequently an existing shop air supply can be used.

Technically this range might be classified as the low-pressure field. There is one special division in this zone known as instrumentation that is entitled to further mention. Here pressures less than 40 psi are encountered, the most common standard being about 15 psi. This low pressure is chosen because it is well adapted to the orifice principle of control commonly found in recording instruments, boiler controls, etc.

Naturally, the lower the operating pressure, the larger the actuating device necessary to produce a given force. Pressures above 125 psi are therefore often required where space limitations will not permit the larger devices required by lower pressures. Weight limitations of pneumatic control devices on aircraft have been so important that pressures of 1500 psi or more are used to keep size and weight at a minimum. High pressure produces correspondingly high actuating forces and permits storing greater amounts of energy in the air reservoirs. However, the higher the pressure the greater strength requirements will be. This means greater refinement in design of elements and higher costs for the pneumatic devices.

Once the maximum pressure required by a system is established then the compressor is selected for a somewhat higher value. First, because most compressors are controlled by a governor that requires some 15 to 30 psi range and, second, because it is frequently desirable to have minimum storage pressure appreciably above maximum pressure required by the system. This will allow for intermittent demands for air in excess of compressor capacity and aid in eliminating moisture from the air.

COMPRESSOR CAPACITY: A compressor should be large enough to supply all the needs of the system. Also, it should have additional capacity to take care of leakage that might develop in the system, future additions to the system, and lower compressor efficiency that may be expected as the compressor approaches the need for major overhaul.

To estimate the air consumption of a system it is necessary to determine the volume of free air per minute or per cycle for each element of the complete system. Where air cylinders or diaphragm chambers are used, the volume of free air used is given by the equation $V = PV/14.7$ where V = volume of free air used in cu ft, P = maximum pressure supplied to cylinder in psi absolute, and V = volume of piston or diaphragm displacement in cu ft.

For pipe volumes, reservoirs or cavities in valves, the volume of free air used is given by the equation $V = (P'V'/14.7) - V'$ where V = volume of free air used in cu ft, P' = pressure to which volume is charged in psi absolute, and V' = volume filled with air in cu ft. These values of V can be determined per cycle of operation and multiplied by the maximum number of cycles per minute to obtain air requirements in cfm.

Where air flows to atmosphere through an orifice the volume of air can be estimated from the data in TABLE 1. For example, the orifice used to eject work from a stamping press may be of 1/16-inch diameter and blow 100 psi to atmospheric pressure for ½-second per machine cycle. If there were 100 cycles per minute this would amount to $6.45 \times 100/2 \times 60$ or 5.4 cfm of free air required.

Another factor affecting compressor size is frequency of demand. If the need for air is continuous, the compressor must be large enough to supply air at the maximum rate required but, where the demand is intermittent, a smaller compressor and adequate storage volume can be used. This permits the compressor to charge the storage reservoir when air is not required so that it will be available for short

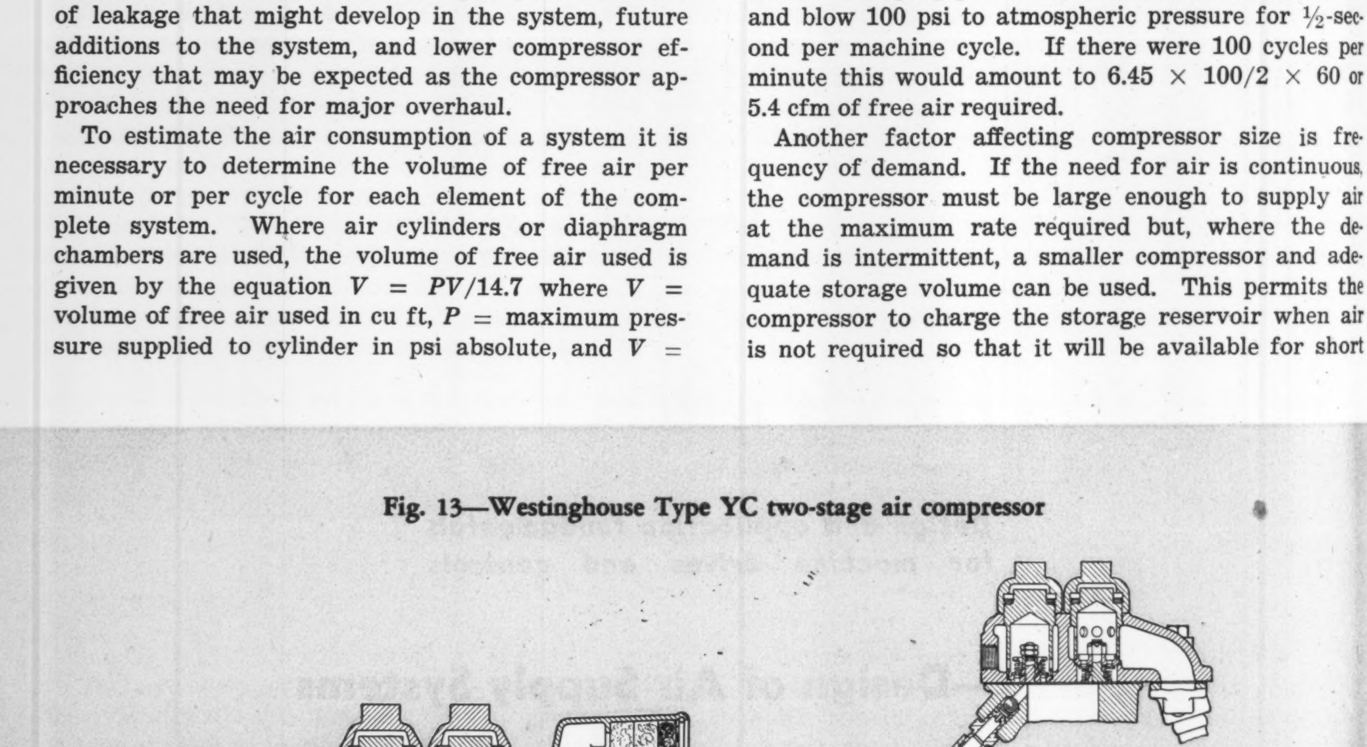


Fig. 13—Westinghouse Type YC two-stage air compressor

ntervals when air is used at a rate greater than the ompressor can deliver. This requires a higher storge pressure and a careful analysis of operating cycles s required to determine the most economic sizes for ompressor and storage reservoir.

Types of Compressors: Rotary, turbine, and reiprocating compressors are the three most common ommercial types. The rotary compressor is small nd compact which makes it desirable where space imitations are critical. However, it is more suited or low pressures because its small size and compactness makes dissipation of the heat of compression difficult.

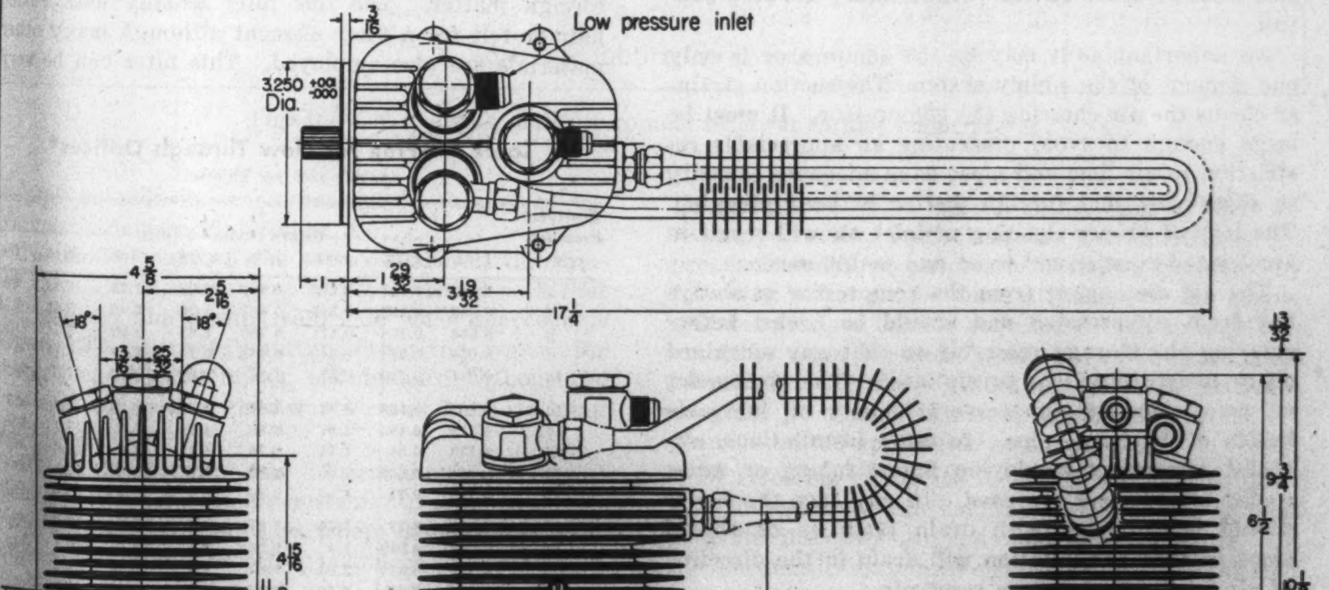
The turbine type compressor is suitable for lowpressure high-volume requirements. Its commercial applications are practically limited to supplying air to combustion turbines, and supercharging diesel and aircraft engines. However, this type of compressor has future possibilities of much wider application if its cost can be lowered and it is designed for higher pressures.

The large majority of compressors for pneumatic systems are of the reciprocating type. They vary in size from fractional horsepower to the largest industrial installations, and in pressure from a few pounds to more than 4500 psi.

The single-stage reciprocating compressor can be built according to many designs and sizes. It is the least expensive in initial cost and is generally used where maximum delivery pressure does not exceed 150 psi. *Fig.* 12 is a typical single stage compressor for general use. There are many single-stage compressors designed for higher pressures but, if operating costs are at all important, a two-stage compressor is desirable for pressures above 150 psi, (*Fig.* 13). The two-stage compressor is more efficient and has lower discharge temperature which means less horsepower consumed and lower maintenance costs. An intercooler is generally used between the two stages.

Where very high pressures are required, two or more stages are used with intercoolers between each stage. These compressors are more costly to produce than those for lower pressures. This in itself is an important factor in determining the pressure for a control system. *Fig.* 14 illustrates a two-stage compressor designed for 1500 psi supply for aircraft controls. It is compact and lightweight. The mounting flange is typical of the mounting arrangement used where a compressor is driven by gear or coupling direct. Except where weight or space requirements are particularly critical it is usually more common to drive the compressor by V-belt or direct. This also permits the compressor to have its own independent lubricating oil supply rather than be dependent on

Fig. 14—A two-stage aircraft compressor designed for 1500 psi service



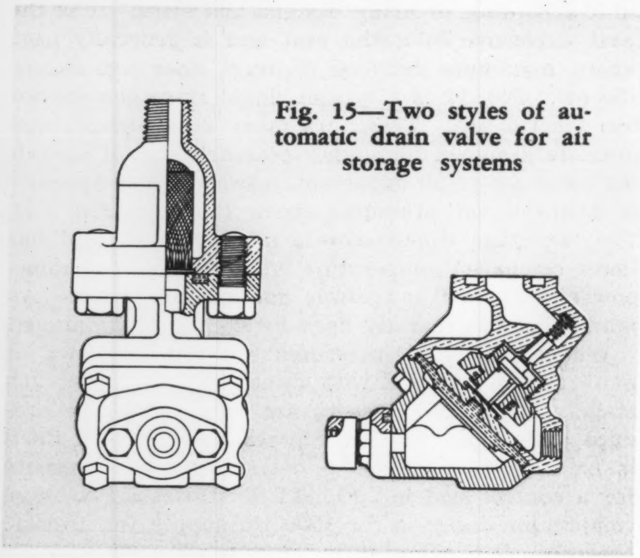


Fig. 15—Two styles of automatic drain valve for air storage systems

the lubricant used in the machine it is associated with.

Where the compressor is driven from a gasoline or diesel engine, or a power take-off from another machine is used, the compressor may run continuously. The pressure is usually controlled by a governor which holds the inlet valve open when a predetermined maximum pressure has been reached, and permits it to close when the pressure drops to the minimum setting. If an electric motor drives the compressor a pressure switch permits start-and-stop control.

As important as it may be the compressor is only one element of the supply system. The suction strainer cleans the air entering the compressor. It must be large enough to avoid presenting an appreciable restriction to air flow and must have adequate capacity to catch dust and foreign matter without plugging. The lack of proper cleaning of inlet air will result in accelerated compressor wear and maintenance.

The air discharged from the compressor is always hot from compression and should be cooled before entering the storage reservoir so that any entrained oil or moisture will be precipitated. The aftercooler on many smaller compressors is only an adequate length of discharge pipe. In other installations, air-cooled aftercolers employing finned tubing or water cooled aftercoolers are used. In any case the cooler should be provided with drain facilities or should slope so that precipitation will drain in the direction of air flow to the storage reservoir.

The storage reservoir must not only be large enough to store the required amount of air, but should be equipped with a drain at its lowest point. The reservoir should be piped so that the air passes through it. To be effective in collecting precipitate the reservoir must have air pass through it at a low enough velocity so that fine droplets of oil or water will settle to the bottom.

The size of reservoir is determined by the amount of air to be stored to take care of intermittent demands beyond compressor capacity. It is also important to have excess capacity to take care of additional operating time in case of a compressor failur This is important where time is required to shu down the machine without spoiling the product o creating a hazard. In some cases, however, the res ervoir is kept to a minimum size to avoid long dela in initial time to build up operating pressure. Wher these factors are not critical, the reservoir is picke with respect to the size required to cool and collec moisture from the air system.

The drain valve can be a manual cock or may b automatic. Automatic drain valves, as shown i *Fig.* 15, are piloted by a timer or the compressor governor. Safety valves and pressure gages are usuall located on or immediately after the first air reservoir To provide adequate protection, the safety valv should have a capacity greater than the compresso at the pressure setting used.

In order that the compressor governor or pilo valve does not foul with carbon, moisture, or oil, i should be supplied with air from the reservoir rather than be connected to the discharge line near the compressor. This insures cooler, cleaner air to the governor.

If air storage is at a higher pressure than is desired at the point where it will be used, a reducing valve can be used after the storage reservoir. The use of a reducing valve also insures a constant supply pressure even though there may be 20 or 30 psi fluctuation in storage pressure due to the range of the compressor governor.

The air leaving the supply system should be cleaned with a line filter to remove rust, pipe scale, or other foreign matter. The line filter usually uses curled hair or felt for a filter element although many other materials are also employed. This filter can be very

Table 1—Free Air Flow Through Orifices*

(cubic feet per minute)

Receiver Pressure (psi)	Orifice Diameter (in.) 1/64	1/32	3/64	1/16	3/32	1/8	3/16	1/
1	0.027	0.107	0.242	0.430	0.97	1.72	3.86	6.8
2	0.038	0.153	0.342	0.607	1.36	2.43	5.42	9.7
3	0.046	0.188	0.471	0.750	1.68	2.98	6.71	11.9
5	0.059	0.242	0.545	0.965	2.18	3.86	8.71	15.4
10	0.084	0.342	0.77	1.36	3.08	5.45	12.3	21.8
15	0.103	0.418	0.94	1.67	3.75	6.65	15.0	26.7
20	0.119	0.485	1.07	1.93	4.25	7.7	17.1	30.8
25	0.133	0.54	1.21	2.16	4.75	8.6	19.4	34.5
30	0.156	0.632	1.40	2.52	5.6	10.	22.5	40.0
35	0.173	0.71	1.56	2.80	6.2	11.2	25.0	44.7
40	0.19	0.77	1.71	3.07	6.8	12.3	27.5	49.1
45	0.208	0.843	1.9	3.36	7.6	13.4	30.3	53.8
50	0.225	0.914	2.05	3.64	8.2	14.5	32.8	58.2
60	0.26	1.05	2.35	4.2	9.4	16.8	37.5	67
70	0.295	1.19	2.68	4.76	10.7	19.0	43.0	76
80	0.33	1.33	2.97	5.32	11.9	21.2	47.5	85
90	0.364	1.47	3.28	5.87	13.1	23.5	52.5	94
100	0.40	1.61	3.66	6.45	14.5	25.8	58.3	103
110	0.43	1.76	3.95	7.00	15.7	28.0	63	112
120	0.47	1.90	4.27	7.58	17.0	30.2	68	121
130	0.50	2.04	4.57	8.13	18.2	32.4	73	130
140	0.54	2.17	4.87	8.68	19.5	34.5	78	138
150	0.57	2.33	5.20	9.20	20.7	36.7	83	147
175	0.66	2.65	5.94	10.6	23.8	42.1	95	169
200	0.76	3.07	6.90	12.2	27.5	48.7	110	195

* Excerpts from PAEA publication *How to Select an Air Compressor.*

Notes: The capacity of an air compressor cannot be checked accurately by use of this table and a narrow edge orifice. Specialized equipment is necessary to check compressor capacity.

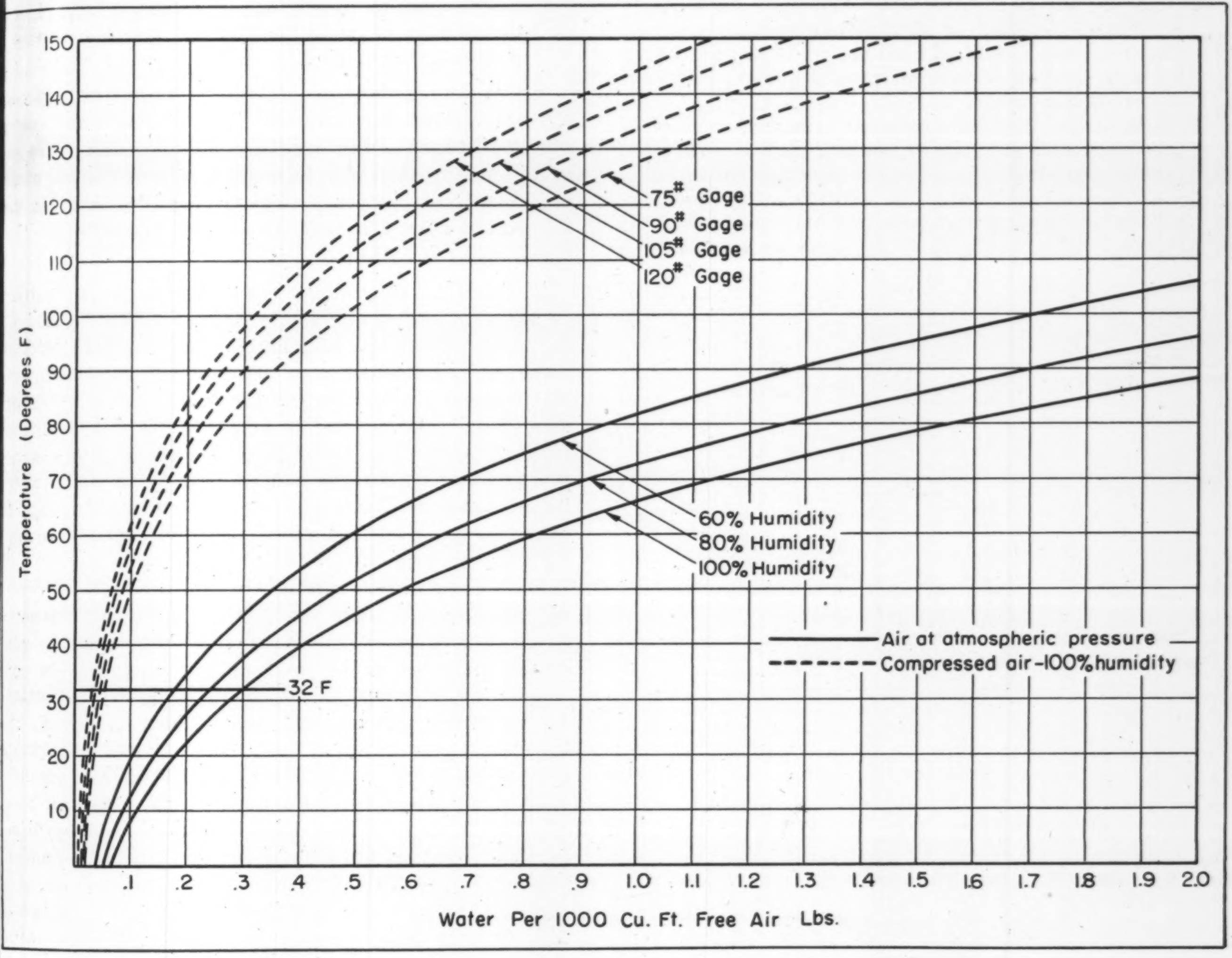


Fig. 16—Chart giving moisture content of air at various temperatures

helpful in reducing maintenance or failure of the pneumatic devices that follow it.

The final element of the supply system is the shutoff valve. It is convenient to use a vented cock that will exhaust the downstream side when the cock is closed. This permits shutting down the system for inspection, adjustment, or maintenance without the waste of air or time that would result from draining the storage reservoir.

OIL AND MOISTURE: Any lubricated compressor will pass some oil into the air system. In some cases, oil may be undesirable such as where delicate valves or orifices are used. In other instances, lubrication in itself is not harmful and may, in fact, be needed. For example, line lubricators are often used to introduce oil for some devices. The important point, however, is that oil discharged from a compressor may have properties that make it undesirable and it can be eliminated by the same means used to remove moisture from the air system.

All atmospheric air that enters a compressor contains some moisture, the amount depending mainly on weather conditions. When compressed, the air can hold less moisture than at atmospheric pressure so it is normal to expect some water to precipitate in the air system. If the water carries throughout the air system it can cause rusting, wash-off of lubricants, corrosion, and otherwise be detrimental to proper function of pneumatic devices. However, by following a few simple rules of design of the supply system moisture can be collected in the storage reservoir or other locations where it can be drained off harmlessly. If these rules are followed, moisture need not be a problem in any pneumatic system, regardless of the application or environment.

By referring to *Fig.* 16 it will be seen that as pressure increases air can hold less moisture and as temperature increases air can hold more moisture. In the pneumatic system, moisture will be precipitated anywhere in the system that the temperature drops to the dew point for the corresponding pressure, unless the moisture has been previously removed. To be sure that moisture does not precipitate beyond the storage reservoir, four rules outlined in the following must be observed:

1. Compress the air to a pressure sufficiently higher than the pressure at which it will be used so that a maximum amount of moisture can be precipitated at the higher pressure. Thus, when air is expanded through a reducing valve its relative humidity will be low enough to hold any moisture that remains

2. Cool the air in an aftercooler that drains precipitate in the direction of air flow to a suitable sump. In most cases it should be cooled to within 3 F of ambient temperature or lower if a water-cooled aftercooler is used
3. Pass the air through a reservoir of sufficient cross sectional area so that air velocity is decreased to the point where any droplets of moisture entrained with the air will settle out. Centrifugal sumps or baffle arrangements may help in this function
4. Drain off the water, preferably with an automatic drain valve, so that it cannot collect in sufficient quantity to be picked up by the air and carried on through the piping.

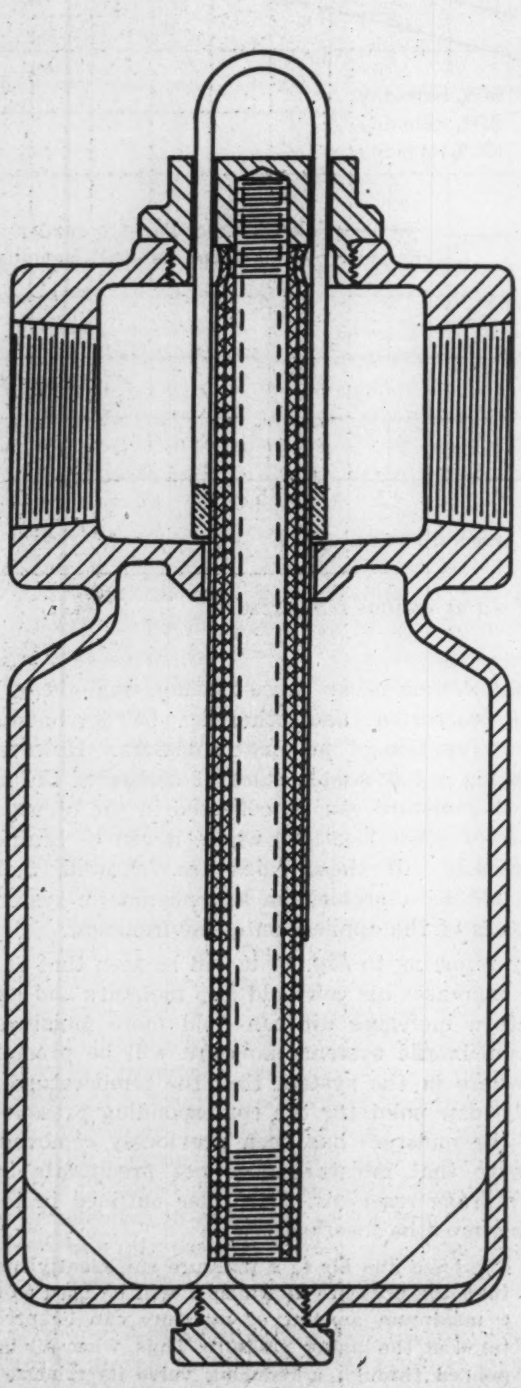


Fig. 17—Alcohol antifreeze unit for use on systems subject to low temperatures

These four points are the most important factors for the designer to watch. There are many other minor factors such as locating the air intake strainer of the compressor where it will not collect rain, snow, or moisture from steam leaks. Also, pockets in the air piping should be avoided where possible, so that water will not collect.

Freezing: Where pneumatic systems are subject to winter weather there is a possibility that the ever-present moisture in air might freeze and restrict or close off the flow of air. To prevent failure due to ice formation, the rules for eliminating moisture should be followed and in addition other precautions may be advisable. If the volume of air used is not too great an antifreeze can be used to keep the water liquid until it is drained from the system. *Fig.* 17 illustrates a wick fed methyl alcohol antifreeze unit for attaching to the intake of the compressor.

Where antifreeze units are not desired, deposits of ice in the system can be controlled otherwise in some instances. Air leaving the compressor is generally hot enough to hold all the moisture it contains. As it cools to the dew point it precipitates no moisture. From this point down to 32 F, the greatest part of the water in the air will precipitate as a liquid. This should be collected and drained from the system before it reaches the freezing zone. The small amount of moisture left in the air will deposit as frost as the air continues to cool to ambient temperature. This frosting should take place in a reservoir or parallel type cooler where the cross-section area is great enough to accumulate frost without undue restriction of air flow.

Eliminating Precipitation and Frosting

The points in the system where precipitation and frosting start are variable depending on weather conditions. It is, therefore, desirable to have a large cross-sectional area for the air to pass through from compressor to reservoir and have frequent points for draining out moisture along the way. This can be accomplished by having two storage reservoirs in series with a parallel type cooler ahead of each one. The pipe connecting the coolers and reservoirs should be short and oversize to accommodate such frost as might accumulate in them. Automatic drain valves and centrifugal sumps are also valuable in removing water before it is cooled to freezing temperatures. This method is effective on mobile machines such as cranes and shovels or stationary machines such as conveyors or hoists. The principles are the same regardless of the size or type of installation involved.

All pneumatic systems are dependent on an adequate supply of clean dry air. The principles of design that will insure such a supply are relatively simple but their proper use is of vital importance to the whole system. Third and final part in this series of articles, "Design, Selection and Application of Pneumatic Components", will appear in a subsequent issue of Machine Design.

PRODUCTION AND
DESIGN
Modern Practices in Manufacture

Reducing Costs of Machine Parts

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GENERALLY there are two spheres of operation in which the problem of reducing costs can be most readily attacked. These can be designated as: (1) Design of product and (2) fabrication methods and processes. So far as the design of a product is concerned, the first requisite is that design be such that the product properly fulfills the function for which it is intended.

Once this basic requirement is taken care of, the designer can turn his attention to considering the manner in which the product can be most economically produced. It is essential, therefore, that the design engineer be thoroughly familiar with all the various types of production equipment which his company has in operation, or available for use.

The design engineer should also have a working knowledge of

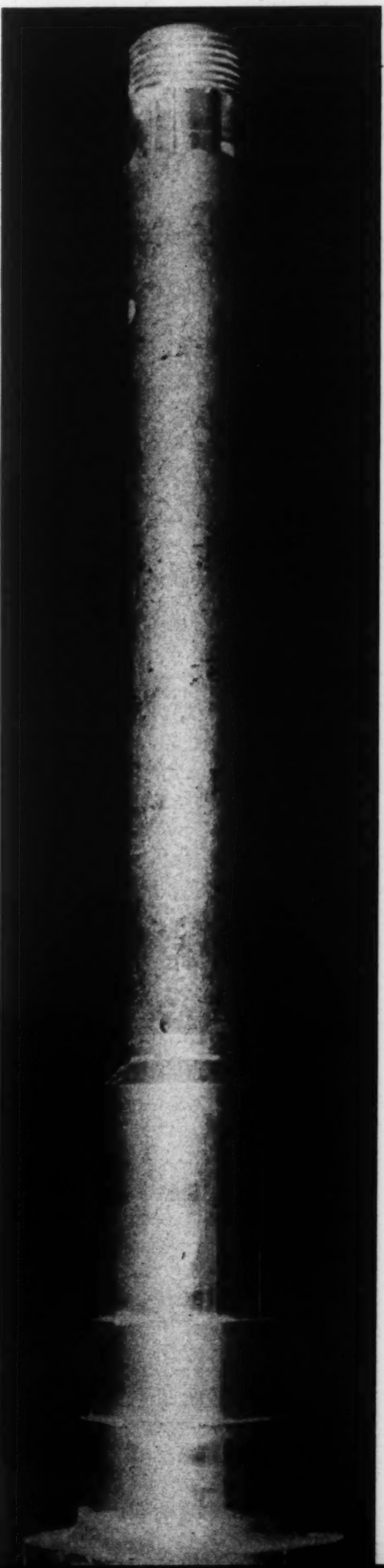


Fig. 1—Right—Motor-generator shaft redesigned for lower costs

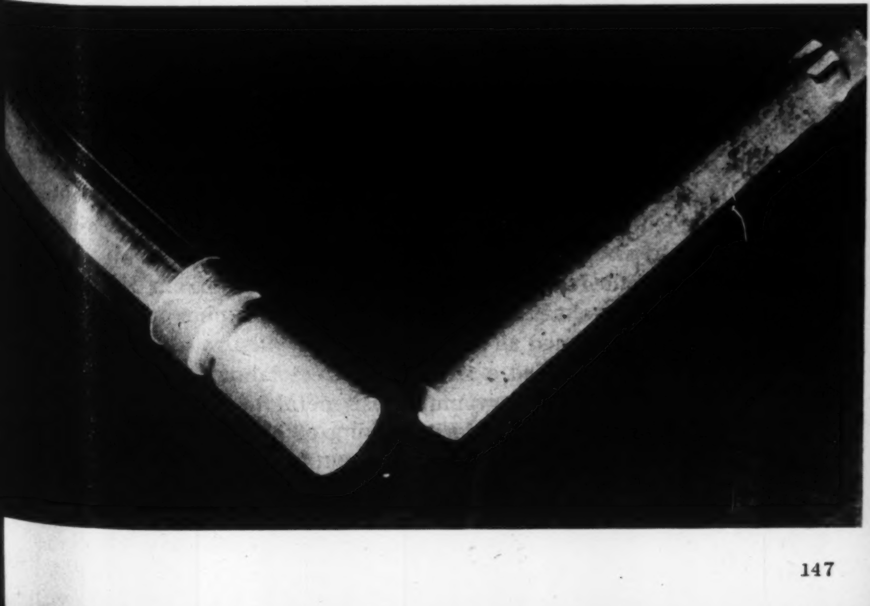
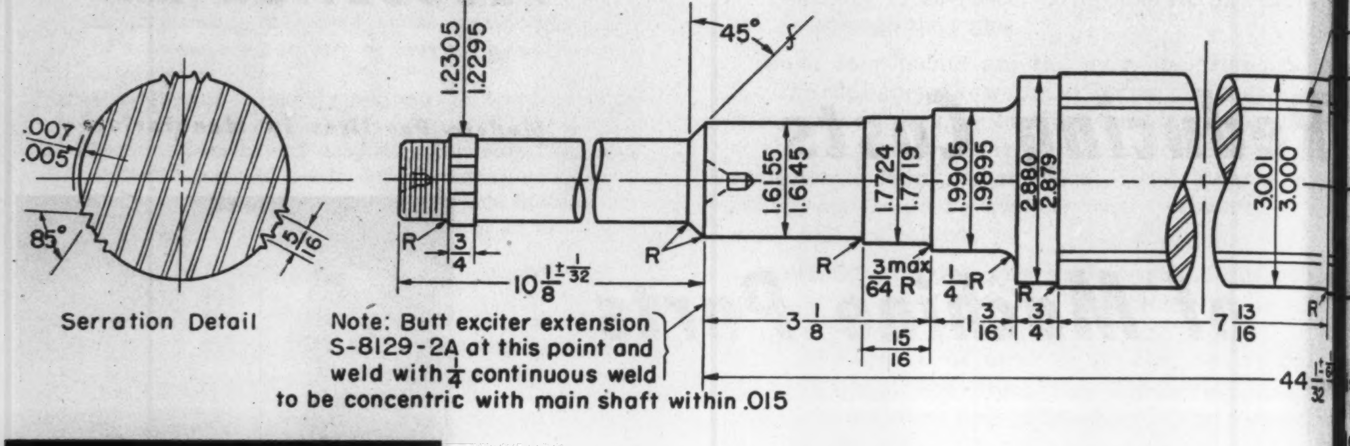


Fig. 2—Below—Redesign of shaft to eliminate machining. Small-diameter extension is cut from hot-rolled stock, upset and welded on



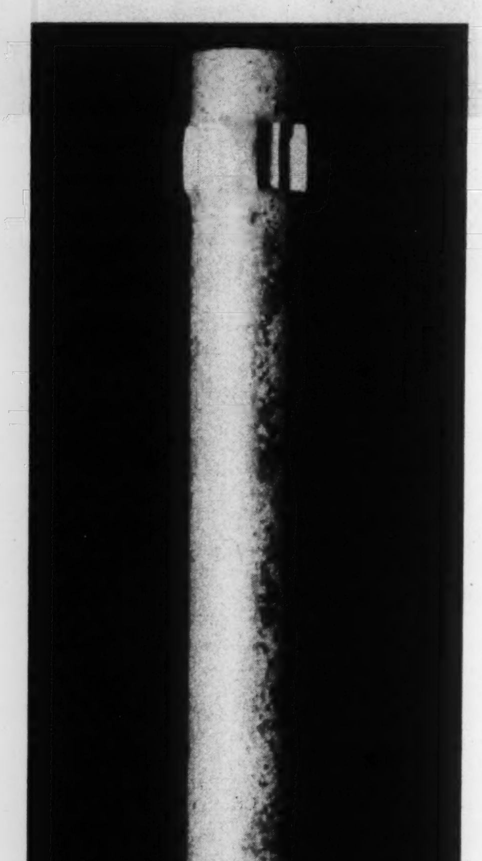


Fig. 3—Shaft parts in position for welding, left, and after completion of automatic hidden-arc weld, right, opposite page

the relative costs of various production processes. For example, if a large number of parts are involved it may be more economical to design the part as a pressing rather than a casting which might require several expensive machining operations.

However, it is hardly to be expected that the design engineer will be as familiar with the details of production equipment, methods and processes as is necessary to insure maximum economies so far as production costs are concerned. Hence, it is advisable that he work closely with methods and process engineers, who may be members of the general engineering staff or who may come under the manager in charge of fabrication.

A concrete example will illustrate some of the points which must be kept in mind if the desired results are to be obtained. The shaft for a motor-generator set, *Fig.* 1, started out in life many years ago by being machined in an engine lathe with the old fashioned high-carbon steel tools. One of the early steps in reducing production costs was the changeover to the use of high-speed steel tools and later to tungsten-carbide tipped tools. Of course when the carbide tools came into use it was necessary to employ much more robust and higher speed lathes in order to take full advantage of the high cutting speeds possible with the carbide tools.

At this point it became very difficult to conceive of further changes which would effect the yearly cost reduction called for by the cost reduction program. Finally the problem was solved by an entirely new approach—through design.

Redesign involved making the shaft in two parts, *Fig.* 2, which, after rough machining the larger part, would be welded together. In production, the two parts are automatically arc welded together with a simple setup near the lathes using the manual Lincolnweld Hi-density hidden-arc process, *Fig.* 3. The weld is 1⅛ inches in diameter and takes about 15 seconds. The shaft is held vertically and the electrode is applied at approximately 30 degrees from the vertical. After welding, the shaft is straightened to within plus or minus 0.002-inch and finish machined as shown in *Fig.* 1.

This change provided a saving in direct labor of 18 cents due to the fact that there was very much less metal to be removed by turning. At the same time a material saving of 85 cents was made, since instead of purchasing over 10 inches of 3⅛-inch diameter stock, all that was required was 10 inches of 1¼-inch diameter stock from which the small-diameter extension is made.

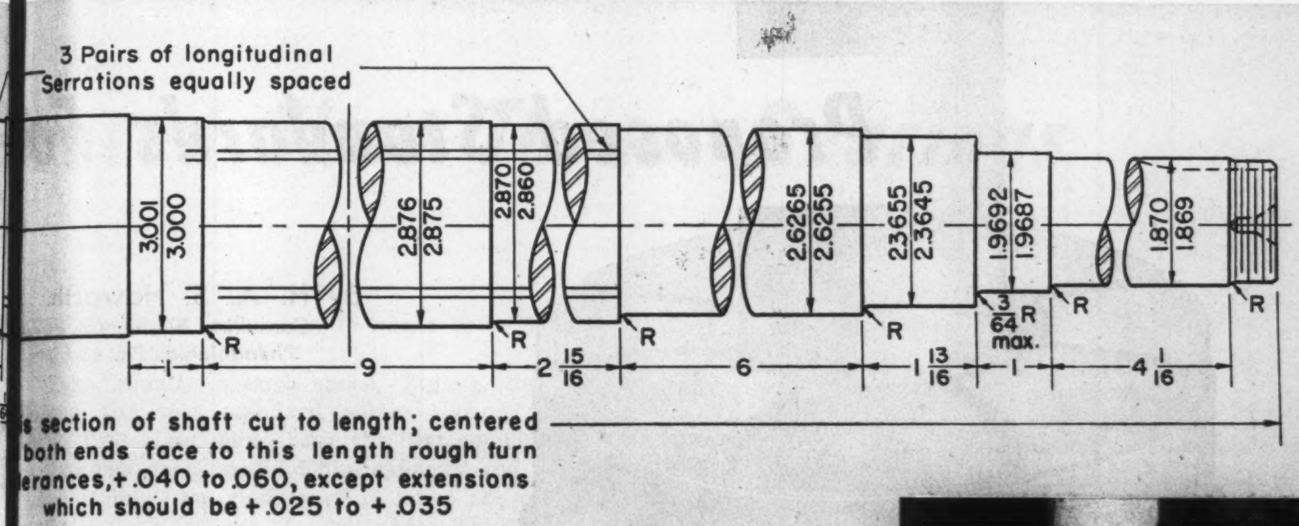
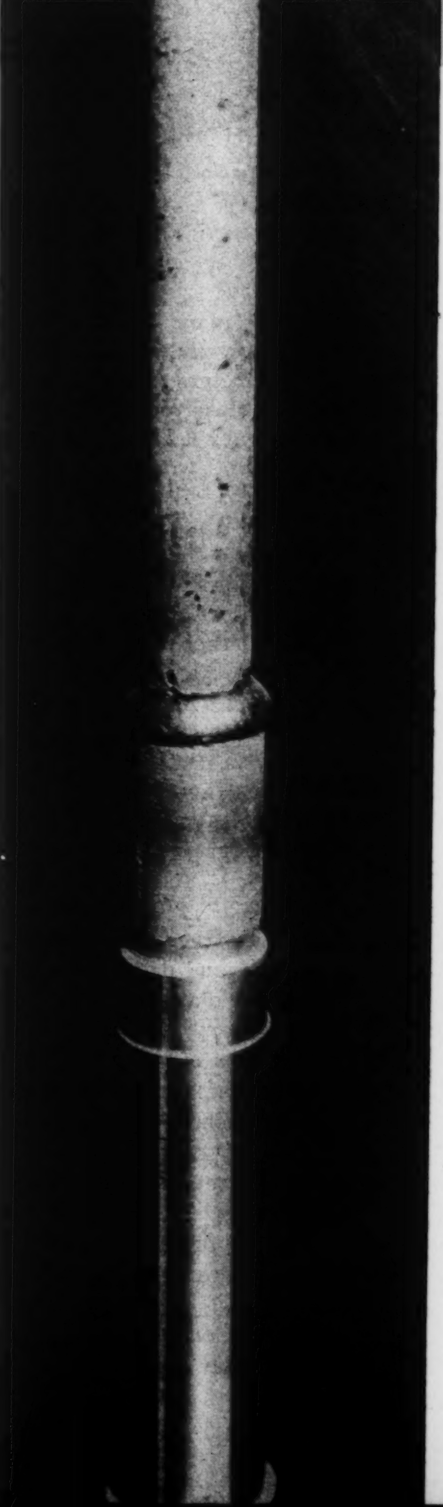

3 Pairs of longitudinal
Serrations equally spaced
3.001
3.000
2.876
2.875
2.870
2.860
2.6265
2.6255
2.3655
2.3645
1.9692
1.9687
1.870
1.869
R
R
R
R
$\frac{3}{64}$R
max.
R
R
1
9
2 $\frac{15}{16}$
6
1 $\frac{13}{16}$
1
4 $\frac{1}{16}$
s section of shaft cut to length; centered
both ends face to this length rough turn
erances, +.040 to .060, except extensions
which should be +.025 to +.035

Fig. 4—Above—Complete shaft drawing showing rolled serration design used to replace machined lamination keyways



This one change secured a cost reduction of approximately twenty per cent, and more than met the cost reduction called for by the cost reduction program in the particular period when the change was made.

On this same shaft another cost reduction has been made which illustrates the importance of ingenuity and imagination in the operation of any successful program of this kind. At the end of the small shaft extension there is a short length which required a slightly larger diameter than the major portion of the shaft. Ordinary design practice would call for a piece of stock of at least the larger diameter to be machined down, thus leaving the short length of larger diameter at the end of the shaft.

To avoid this machining, a collar was welded on and this resulted in a small saving of both labor and material. However, more thought was given to this particular problem and a design was evolved which eliminated the welded-on collar entirely, effecting a double cost reduction—in material and direct labor. The idea was to form a partial collar on the shaft by means of displacing some of the shaft material itself. An inspection of the small end of the shaft will indicate the simplicity of the operation, *Figs.* 1, 2 and 3. This upset collar, which provides a seat for the exciter armature, is turned to diameter after the upsetting operation.

Another design innovation which resulted in cost savings is the method of securing the armature laminations onto the shaft. Both key and keyway have been eliminated and in their place three sets of special serrations are rolled into the shaft, *Fig.* 4. These serrations permit pressing the laminations onto the shaft without complication and are produced in a special vertical machine designed for this purpose. Rolling these serrations instead of milling keyways and using keys reduced costs about 10 cents per shaft.

CONCLUSION: Perhaps the most needed characteristic in cost reduction work is that of imagination. Unfortunately, this characteristic is all too scarce. Nevertheless, every designer has some measure of it and this is capable of development. It is one of the more important duties of engineering management to develop this valuable characteristic in those whom they direct. It is a fact that every method and every process employed today can be improved. The knowledge will assist in the development of imagination and it cannot be repeated too often or emphasized too much. Every product can be improved and its cost in man-hours and materials can be reduced.

Proposed Standards Fo

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PUBLISHED standards for pivoted shoe thrust bearings show that between 12 and 24 inches the outside diameters of the shoe faces for successive sizes vary closely as the sixth root of 2. Since the net areas vary as the square of the diameters, the third root of 2 would be the progressive rate of capacity increase. Below 12 and above 24 inches these increments have not been held to consistently. However, because these increments are reasonable, the author proposes to use them as the basis of a standard, consistent series of sizes that may be followed in the further development of such bearings.

It is proposed that a set of rational sizes should have a basic series of outside diameters, each twice as large as the preceding one: 3, 6, 12, 24, 48, 96, and 192 inches. Between each successive pair of these basic sizes there would be five other diameters determined by multiplying the lower of the basic sizes by the factors: 1.00000, 1.12246, 1.25992, 1.41422, 1.58740, 1.78179 and 2.00000 which represent, respectively, 2^0, $2^{1/6}$, $2^{1/3}$, $2^{1/2}$, $2^{2/3}$, $2^{5/6}$ and 2.[1]

The complete series of proposed diameters is tabulated in TABLE 1 and designated D. Values are given to three decimal places, but can easily be calculated to five, if necessary, for maintenance of accuracy in the determination of other proportional dimensions. The principal diameter, D, could also be expressed to the nearest tenth of an inch and be called the *nominal size*. By dropping the decimal point of this nominal size, a series of *size numbers* is obtained. Thus bearing No. 302 would have an approximate outside diameter of 30.2 inches, tabular value D = 30.238, and a more exact diameter of D = 30.23808 inches.

Just as the rational series of diameters, D, was determined, a similar series of desirable housing bores, C, was found. It has been customary to make that bore about 6 per cent larger than D. Hence, the twelfth root of 2, which is 1.05946, may be used as a factor. The resulting diameters are also listed in TABLE 1.

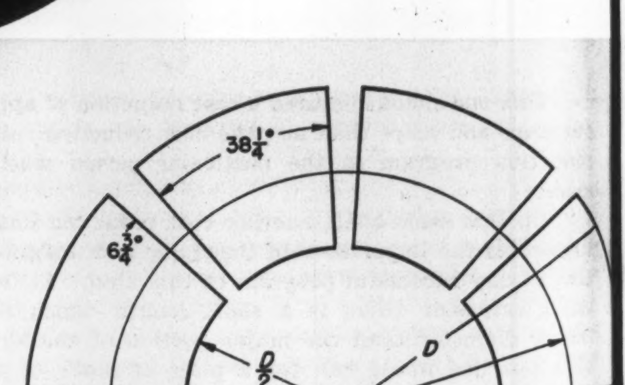


Fig. 1—Proportions of 8-shoe thrust bearings on which this proposed standard is based

If an intermediate bearing size is needed between those listed in the D column, the twelfth root of 2 would be used to determine the diameter, D, hence the intermediate size could be taken from the C column. A suitable housing bore for this size bearing would then appear as the next higher diameter in the D column. For example, if a size between

ivoted Shoe Thrust Bearings

3.780 and 4.243 is needed, D would be 4.005 and C would be 4.243.

Eight equally spaced shoes, *Fig.* 1, have been chosen for this standard series because analysis shows that eight shoes have the best combination of mechanical strength, fluid film capacity and low friction. It has been customary to make the total face angle of each full set of eight shoes 306 degrees, or 38¼ degrees per shoe. Hence, the net area of eight 38¼-degree shoe faces would be $(\pi/4)\ (D^2 - D^2/4)\ (306/360)$ or very closely $D^2/2$ when the shoe bore is $D/2$. The net area is 306/360 or 85 per cent of the available surface. The remaining 15 per cent is used for oil channels. With the same area ratio and six shoes, each shoe would subtend an angle of $0.85 \times 60 = 51$ degrees.

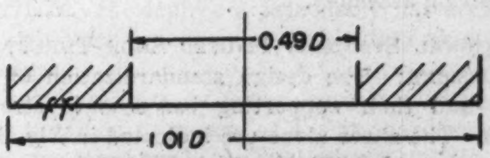
Capacity and friction have been discussed at length elsewhere and tables given for both thrust and radial bearings, each having eight pivoted shoes, (MACHINE DESIGN, "Load Capacity of Pivoted-Shoe Bearings, Parts I and II, July and August, 1948).

Thrust Face Dimensions

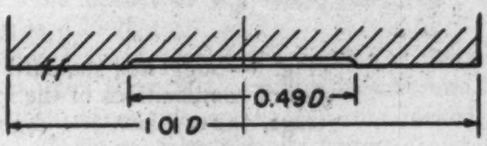
A series of rotating thrust faces as generally used with pivoted shoes is shown in *Fig.* 2. Thrust faces of a hub and of a shaft end are shown and dimensioned in *Figs.* 2*a* and 2*b*. This face should overlap the faces of the shoes, inside and outside, by 1 per cent of the diameter, D. This overlap is indicated also in the other thrust faces, *Figs.* 2*b* to 2*f*. Other standardized proportions include the thicknesses of integral and removable thrust collars, *Figs.* 2*c* and 2*d*. These two collars must be strong enough as rings or plates not to be overstressed where they join or are bolted to the shaft.

The rational series of diameters can furnish dimensions not only for bearing elements but also for their mountings and for the shafts with which they are used. The nominal average or mean diameter of standard shoe faces is 0.75 D, as can be seen from inspection of *Fig.* 1. Minimum and maximum diameters for shafts with integral thrust collars, *Fig.* 2*c*, when used with standard shoe faces are 0.375 D and 0.445 D, respectively. If neither of these shaft sizes can be used, two preferred intermediate diameters, 0.397 D and 0.420 D, are included in the proposed standard. The bore of a removable collar for standard shoe faces, *Fig.* 2*d*, is 0.397 D. Diameter of a shaft with a removable collar used with standard shoe faces, as in *Fig.* 2*d*, is 0.472 D. The inside diameter of standard shoe faces is 0.5 D, from *Fig.* 1, and the inside diameter of a standard base is 0.5 C.

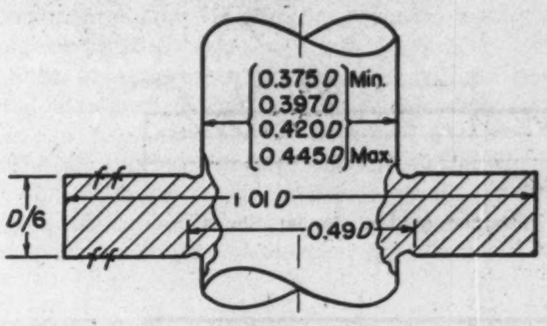
Fillet diameters at the shaft for an integral collar



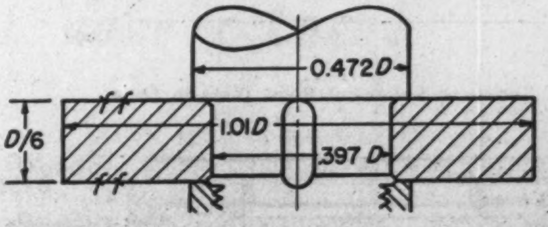
(*a*) Hub Face Finished for Bearing



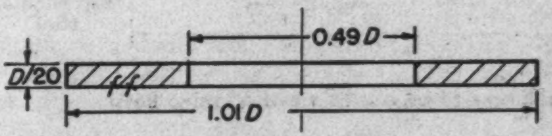
(*b*) End of Shaft Finished for Bearing



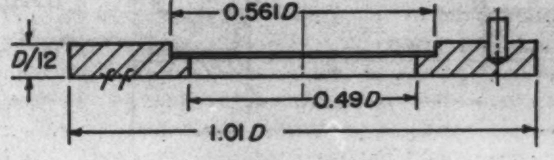
(*c*) Integral Shaft Collar Finished for Double Bearing



(*d*) Removable Thrust Collar Finished for Double Bearing



(*e*) Thin Facing Collar



(*f*) Thick Facing Collar

Fig. 2—Proportions of rotating thrust faces usually used with pivoted shoe thrust bearings covered in suggested standard and shown in Fig. 3

may be equal to the radial distance from the base of the shoes to the turn of the shaft. The fillet should be cut slightly below the collar face to permit lapping of the face. Radial margin of the face within the shoe base should not be less than 0.005 *D*. Diameter of the dowel pin circle, *Fig.* 2*e,* is 0.8118 *D*. It should be noted that the standard shaft sizes are all in the twelfth root series, extended downward.

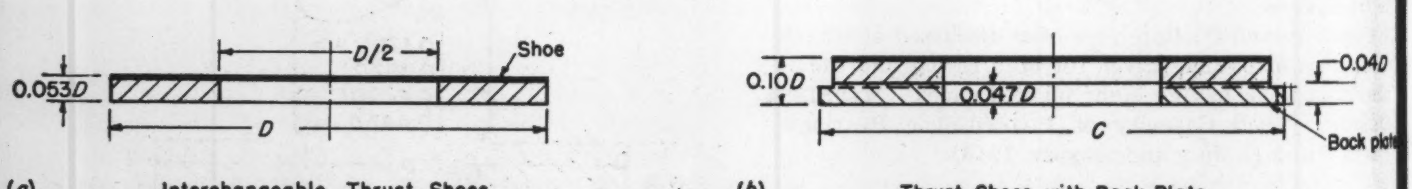
In establishing dimensions of fitting parts the minimum should be chosen for a bore and the maximum for a turn. The bearing designer should supply a table of recommended tolerances for parts which join the bearing assembly.

RATIONAL STANDARD PIVOTED SHOE THRUST BEARING DESIGNS: The design standardization of thrust shoes and their supporting bases is illustrated in *Fig.* 3. The shoes alone are indicated in *Fig.* 3*a* with a thickness of 0.053 *D,* which is sufficient for eight babbitt-faced steel-bodied pivoted shoes to carry the rated load, when mounted as in *Figs.* 3*b* to 3*h*. The dowels or other means that hold the shoes in place are not indicated, as they might differ with the manufacturers. However, it is proposed, for the series of designs now to be described, that the shoes shall be alike and interchangeable throughout.

Spherical Pivots Permit Tilting

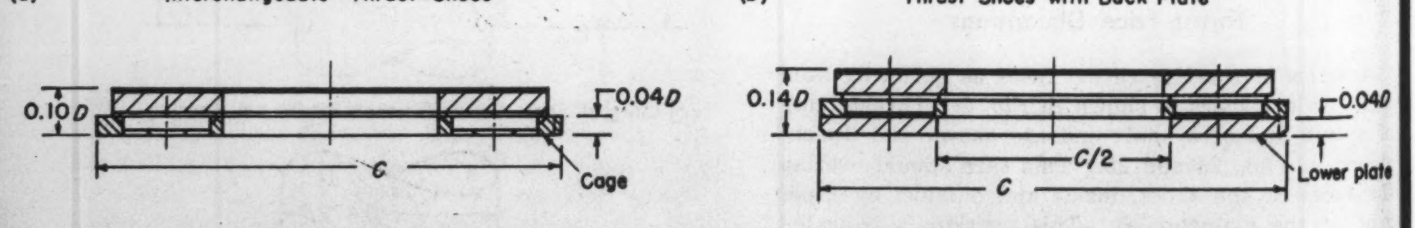
The simplest mounting for shoes is that of *Fig.* 3*b.* Radial tilting is not provided for on the shoe elements or on the ring or back plate upon which they rest and to which they are fastened to form this combination. The ring or back plate is, however, formed to permit the essential circumferential tilting of the shoes. It can be held against rotation by means of the key shown in its rim, or otherwise. The

Fig. 3—Suggested standard thrust bearing designs. Various styles are made up of combinations of the following shoes, back plate, spherical pivot disks, cage, lower plate, self-aligning base, equalizing base, and adjustable base



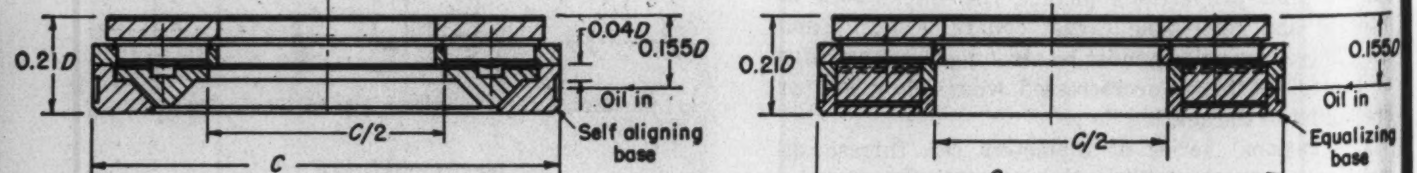
(a) Interchangeable Thrust Shoes

(b) Thrust Shoes with Back Plate



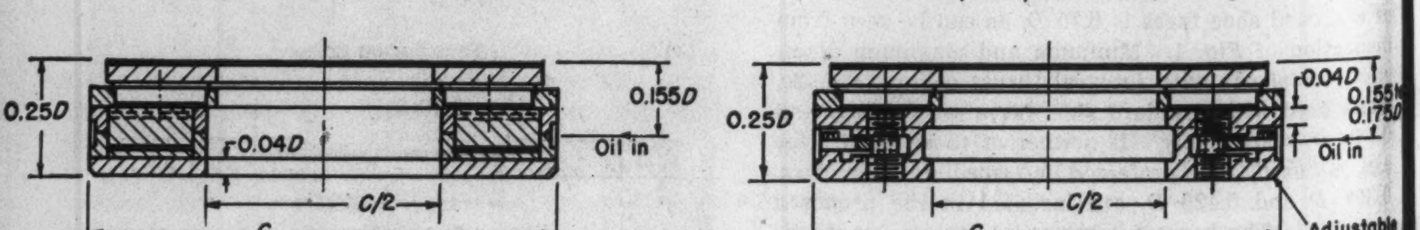
(c) Thrust Shoes on Spherical Pivot Disks in Cage

(d) Thrust Shoes, Disks, and Hard Lower Plate



(e) Thrust Shoes, Disks, and Thin Self Aligning Base

(f) Thrust Shoes, Disks, and Thin Equalizing Base



(g) Thrust Shoes, Disks, and Equalizers on Hard Lower Plate

(h) Thrust Shoes, Disks and Adjustable Base

Table 1—Proposed Diameters for Series of Pivoted Shoe Thrust Bearings

(inches)

Outside diameter of standard shoe face D	Inside diameter of housing for bearing cage C	Outside diameter of standard shoe face D	Inside diameter of housing for bearing cage C	Outside diameter of standard shoe face D	Inside diameter of housing for bearing cage C
3.000	3.178	12.000	12.714	48.000	50.854
3.367	3.568	13.470	14.271	53.878	57.083
3.780	4.005	15.119	16.018	60.476	64.072
4.243	4.495	16.971	17.980	67.883	71.919
4.762	5.045	19.049	20.181	76.195	80.726
5.345	5.663	21.381	22.653	85.526	90.612
6.000	6.357	24.000	25.427	96.000	101.708
6.735	7.135	26.939	28.541	107.756	114.166
7.560	8.009	30.238	32.036	120.952	128.145
8.485	8.990	33.941	35.959	135.765	143.838
9.524	10.091	38.098	40.363	152.390	161.452
10.691	11.327	42.763	45.306	171.052	181.224
				192.000	203.416

overall combination height is 0.10 *D*.

In the next combination, *Fig. 3c*, the shoes are mounted on disks with hardened spherical pivots that permit tilting in any direction. For durability the deck should be hard where the pivots rest. The plate and disk element combined with the shoes have an overall height of 0.10 *D*.

The combination of *Fig. 3d* includes a lower plate that is hardened where the shoe support pivots rest upon it. The height of this combination is 0.14 *D*.

The forms previously described require a thrust deck that is square with the shaft in order that the thrust load shall be equally distributed over the shoes. When the deck is initially out of square with the shaft, or when it may become so under load or with time, the shoes should be supported by some aligning means. One such means is a pair of spherically mated rings, as seen in *Fig. 3e*. When used with the elements of the *Fig. 3c* bearing there results the combination, shown in *Fig. 3e*, that is self-aligning but not sensitively so. Its overall height is 0.21 *D*.

A sensitively aligning supporting means is shown in *Fig. 3f*. It is combined with the style shown in *Fig. 3c* to produce a bearing whose overall height is also 0.21 *D*. It requires a reasonably flat deck upon which the lower equalizers may rest their blunt radial knife edges.

Greater durability of lower equalizer tilting contacts is obtained by means of a plate hardened locally, and combined with the type shown in *Fig. 3f* to produce the design of *Fig. 3g*. The height of this bearing is 0.25 *D*.

Another way to mount the shoes for distributing the load upon them is to employ jack screws, which are readily adjustable under load and locked, as in *Fig. 3h*. Their use also permits height change. The adjustable base of this bearing, together with the components shown in *Fig. 3c*, produces a unit with a height of 0.25 *D*.

Split bearing bases are possible within the tabulated standard dimensions for styles shown in *Fig. 3 b, c, d, f, g* and *h* but not with type *Fig. 3e*.

The shoe retaining ring, shown in *Fig. 3b*, or the support retainer, shown in *Fig. 3c*, could be made in halves when required to permit radial removal of shoes from otherwise solid bearing bases.

Amplidyne Drive for Veneer Lathe

AMPLIDYNE and electronic control will be used to provide a completely co-ordinated drive on a veneer lathe, pressure roll, tipple and trays for Puget Sound Plywood Inc., Tacoma, Washington. In operation, a thin sheet of veneer is peeled by a knife from the full length of the log placed between two chuck centers. The knife is advanced at a specified rate so as to produce a continuous sheet of uniform thickness. The sheet is in turn picked up by the tipple which feeds the veneer to storage trays arranged in a stack, one above the other. The veneer lathe drive is a direct-current system, utilizing amplidyne control to obtain the maximum performance from the drive components. Key to the drive is the use of an amplidyne exciter. In appearance and maintenance, the amplidyne resembles a conventional direct-current exciter. However, where the ratio of power output to excitation power for a conventional exciter may be 25 to 1, the same ratio is 1000 to 1 for the amplidyne so that the drive is controlled by currents which usually amount to a fraction of one ampere.

The drive, designed by General Electric Co., holds constant veneer cutting speed as the log diameter changes. The unique combination of a motor-mounted tachometer generator and knife-operated rheostat produces a voltage directly proportional to veneer sheet speed. This voltage is balanced against a fixed voltage and any difference is impressed across an amplidyne control field. Since an infinitesimal amount of amplidyne excitation controls the amplidyne output, this small voltage difference controls the speed of the driving motor.

The co-ordinated drive also includes a 7½-hp motor to drive the tipple conveyor, and a 15-hp motor to drive the storage trays. Control is arranged so that the speed of the tipple and tray conveyors will be equal to and will follow linear sheet speed of the peeled veneer as it comes from the lathe. A 3-hp pressure-roll Thy-mo-trol drive maintains constant torque on the roll above the knife. Standard wound-rotor motors with 50 per cent fixed secondary resistance are commonly used for this application. Speed of the entire system is controlled by a master speed-control lever and all drives will stop when the control is in the off position.

Selection of Mat

. . . must be guided by more than conventional tests and data

By H. W. Gillett
Chief Technical Adviser
Battelle Memorial Institute
Columbus, Ohio

AN ENGINEER sometimes finds behaviors in service that he did not foresee because the metal he used had not been checked for all its behaviors in just that service. Some of these cases prove dangerous and expensive. Examples are the failures of cables of the Mount Hope and the Ambassador bridges, in an advanced stage of erection, requiring replacement at a cost of several million dollars; embrittlement and fracture of steam piping after years of service at high temperature in a power plant; explosion of a tank storing flammable liquefied petroleum gas at low temperature, involving a bad fire and several deaths; breaking in two of welded ships during the war; and many instances of less spectacular failures in less important structures or machines.

In the instances cited, specifications were drawn and tests made, based on behavior under conditions not exactly those of service, which raised the expectation that performance would be satisfactory. Postmortem studies showed that, instead of the behaviors being freaks, they were what might, with better knowledge, have been expected. Remedies then became apparent.

Service Conditions: Metals do behave just as they have to, from their composition and structure, under the imposed conditions. Their behavior does not vary, as the small boy's is supposed to do just before Christmas, or as that of other humans does depending on what they did, or ate, or drank the night before.

There is more to the choice of metals than just avoiding failure in service. As knowledge and technique advance, it is always an open question whether entirely satisfactory service cannot be obtained by use of an alternate, cheaper material, or an alternate, cheaper method of fabrication, utilizing a material fitted for the new fabrication method.

An interesting discussion[1] of the savings often secured when problems of redesign and of alternate materials are brought up gives case histories and a list of pertinent questions to be asked, in so-called "value analysis." One of them is: "As the part is studied, imagine that you are forbidden to use it. How, then, would the job be done?" A similar question would apply when the prohibition refers to a previously used material.

Even the nontechnical executive might profit by enough grasp of the behavior situation to set his technical men to examining both the design and the materials in a present or a planned product from such a point of view. There is little need for others than the metallurgical specialists to delve deeply into the causes and remedies for the idiosyncrasies of metals, but there is dire need for understanding by those others of what limitations their own designs and their own service demands set to the performance of metals.

Effects of Design on Behavior: It is generally considered that the lion's share of all failures in service comes from fatigue (i.e., progressive failure under repeated stress) and one automotive engineer,[2] in a deservedly oft quoted comment, places the responsibility as follows: "Fully 90 per cent of all fatigue failures occurring in service or during laboratory and road tests are traceable to design and production defects, and only the remaining 10 per cent are primarily the responsibility of the metallurgist as defects in material, materials specification, or heat treatment."

. . . metals do behave just as they have to . . . their behavior does not vary, as the small boy's is supposed to do just before Christmas . . .

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[1] References are tabulated at end of article.

tials

a sequel to "Mechanical Properties of
tals," which appeared in March, this ar-
le is also based on a new book by the
e Dr. Gillett. His pungent observations
valuable counsel on many aspects of
terial selection—an ever-complex issue

In relation to gas-turbine design, Young[3] says, "Equal attention must be paid to exact temperature and time at temperature as well as stress. With a thorough investigation of these variables, proper consideration for limitations of present alloys, and with a growing background for an understanding of these limitations, substantial improvement can be effected without resort to a Utopian material permitting unlimited power and efficiency with a minimum of design effort."

As an example of the effect of design, take the case cited by Wood and Sanders[4] who developed an apparatus for studying the resistance of steering knuckles to repeated overstress, using actual full-size knuckles rather than endurance specimens, and applying measured forces of the magnitude and direction met in service. They first determined the range of lives at the selected stress, given by several lots of knuckles made from a certain steel (X 3140) that had previously been used in production, and then by those made from several other steels. In this comparison, another steel, 4140, gave knuckles that tested slightly better than X 3140, but the supply situation was shifting so that 4140 would not be available. A third steel was then tried and gave a wide scatter in results at first, but after engineering modification of fillet radii, the scatter was reduced to normal and the average life increased.

In turn this third steel became unavailable, so NE 8744 was tried. The average and high values were satisfactory, but some low results were obtained. Shot-blasting the area of stress concentration was then resorted to. The *low* fatigue-life figure for this one selected stress rose to 639,000 against a *maximum*, with the original X3140 knuckles, of 241,000!

The search for a metallurgical substitute developed the fact that feasible engineering modifications were so much more potent than steel composition that the final results, using a mildly alloyed steel plus some mechanical engineering attention, far surpassed those without that attention.

COMBINATION OF REQUIREMENTS: In early days, crankshafts universally were forged steel, and stringent specifications and tests were imposed to insure that the shaft would bend and be very tough. Finally, the fact percolated through that a bent crankshaft is as useless as a broken one and that it does not require toughness, for it does not need to resist severe impact in service. Millions of Ford cast crankshafts, not capable of appreciable bending and quite brittle, but properly rigid and wear-resistant, are in successful use. The cost of the machined cast shaft is significantly lower than for the forged one.

We are prone to think that the stronger a material is the better it is. On this basis steel pipe would be better than soft copper tubing. However, for carrying water to the various household taps, if the water is of a type not corrosive to copper, the more expensive copper may be the better, because a long tube can be snaked around corners where the steel pipe would have to be in sections and ordinarily joined by threaded connections. So the extra cost of the copper may be largely made up by low installation cost. The strength of copper is ample for the use, the extra strength of the steel is of no value. Moreover, if the pipes happen to freeze, the soft copper will give instead of bursting. No one mechanical property but rather a set of mechanical and physical properties are the criteria of suitability for almost any service you care to name.

THE QUESTION OF DUCTILITY: For such applications as gas-turbine rotors, designers are prone to demand considerable ductility, which comes as a sacrifice in strength. Conventional ductility values as obtained in a tensile test have been taken as the criterion. Holms and Jenkins,[5] of the NACA, examined the validity of this criterion by comparing tensile ductility with bursting tests of rotating disks, both solid and with central holes of varying sizes.

Beyond the point of maximum load in the tensile test, when necking begins, there is a region of instability. They consider that, for high-speed rotating disks, ductility criterion is the reduction of area at the maximum load, before necking starts, rather than the conventional elongation or reduction of area after fracture.

They examined steels, beryllium copper, stainless steel, brass, and a nickel-base alloy, in which the

. . . insistence . . . upon high tensile ductility is seldom justified . . .

. . . there is little need for others than the metallurgical specialists to delve deeply into the causes and remedies for the idiosyncrasies of metals . . .

conventional elongations varied from $3\frac{1}{2}$ to 53 per cent, conventional reductions of area from $3\frac{1}{2}$ to 70 per cent, reductions in nonnecked area from 0.8 to 17 per cent. Some of these alloys were weak, down to 58,000 psi tensile, some strong, up to 190,000 psi tensile.

The strong, low-ductiilty materials showed as good utilization of strength as did the more ductile ones, and this held whether the disks were solid or had central holes. Indeed, the authors say that the strength of the disk with a large central hole decreases in the range of high ductility. The only effect of ductility was that, when the disk was rotated at a speed sufficient to fracture it, the more ductile materials broke into only two or three pieces, the less ductile into more pieces.

. . . the belief that ductility figures are direct and accurate gages of ability to be cold worked or of avoidance of shattering failure is without basis . . .

An opposite point of view is expressed by Saldin and DeHuff,[6] who tentatively conclude, on the basis of very few tests, that hot ductility is needed in jet-engine rotors. But they give no definite idea as to how much ductility is needed. Manson,[7] discussing the combined effect of centrifugal and thermal stresses on turbine disks, comments, "As yet, experimental data are very meager on the significance of ductility."

Many metal objects neither have nor need appreciable ductility. Despite the severity of their service, railroad rails have only vestiges of ductility. Used rails are cut up into head, web, and base, reheated, and rerolled into smaller shapes. This brittle high-carbon rerolled rail stock serves excellently for fence posts, rails to support the springs of beds, and like uses where no cold forming, welding, or severe impact or repeated stress is involved. This cheap material is one for the designer to keep in mind.

The amount of tensile ductility that can be actually utilized in ordinary service of metals has been much discussed. The opinions of various authorities cited[8] concur in such figures as 1 to 2 per cent elongation, and in modern studies of brittle behavior[9] in large steel sections it is found that something like 1 to 3 per cent deformation is all that can be utilized. Permanent deformation of $1\frac{1}{2}$ per cent in an airplane wing would destroy its aerodynamic efficiency.[10] Satisfactory big guns have been made in the United States with tensile elongation, on radial specimens, as low as 5 per cent.[11] Commercial steel plates showing 30 per cent elongation, 65 per cent reduction of area, on longitudinal specimens frequently show but 2 per cent elongation and 5 per cent reduction of area in the through-plate direction.[12]

The belief that ductility figures are direct and accurate gages of ability to be cold worked or of avoidance of shattering failure is without basis. The insistence in specifications upon high tensile ductility is seldom justified from the point of view of the designer, who can allow his product to display but a tiny fraction of that permanent deformation.

Factors in Selection: Three important questions crop up in the selection of materials and of fabrication methods: How many duplicate pieces are we going to make? How long do we want them to last? How serious is an occasional failure?

Quantity Production: If many thousand duplicate pieces are to be made, the high cost of tooling may be justified for deep drawing, die casting, forging, powder metallurgy, or precision casting. The same is true of equipment for centrifugal casting, of specially designed welding equipment or of special machine tools adapted to one job only. Moreover, there should be a careful choice of a metal amenable to the fabrication method to be used and, of course, suitable for the service conditions.

The lower cost of quantity production is thoroughly recognized. If only a few pieces are to be made, slow hand methods and relatively expensive metal that happens to be in stock, perhaps of far higher properties than the service really demands, may easily be the economic choice. The greater the production will be, the more attention needs to be paid to the idiosyncrasies of metals.

. . . the greater the production . . . the more attention needs to be paid to the idiosyncrasies of metals . . .

Life Expectancy: How long a structure, a machine, or a part is intended to last affects the choice also. How long it *will* last depends largely on the type of use or abuse it gets in service. A rear axle gear is not designed to stand continuous overload that would cause early fatigue failure but it must stand, say, a few hundred such overloads in a passenger car and many more in a heavy-duty truck. The behavior of steel in high-temperature service or in applications involving corrosion or wear varies widely with the conditions under which it must serve. Interior or exterior exposure and the nature of the atmosphere control the rate and type of corrosion.

The life desired depends on the service. A bridge is expected to last a lifetime, a watch or a steam turbine for a power plant 20 years. But a tin can need hold its contents only for a year or two. Its expected shelf life is often short; it is thrown away after a single use. A rocket motor may need to operate but a few seconds, a locomotive engine for many years.

We expect, in many instances, to discard an object for obsolescence just because a better or more attractive object of its class has by that time been devised. It causes little more grief if the replacement is necessary because the article has given out. What behavior we need varies with how "expendable" the object is. We do not design children's toys as we do a diesel engine.

When chemical corrosion occurs, it may be cheaper to use relatively corrodible pipe, valve, or tank maerial, let it corrode, and replace it from time to time, rather than to use an incorrodible, far more xpensive one. If the chemical is injured by the corrosion product, the situation changes and the incorrodible material may be the best and cheapest.

In some services such as the power-plant turbine, we like an object to have the "one-hoss shay" characteristics, with no need to shut down for replacement of any part. In others, such as a plow, we expect the plow point to wear, and be replaced, and so it is made detachable. The cost of interruption of production in the down time for replacement frequently is as important a factor as the cost of the new part.

Seriousness of Failure: The seriousness of a failure is another factor. We cannot endure many failures of aircraft engines or their parts in service, whereas failure of an automobile spring is not so serious. A leak in a tank holding a flammable liquid or gas is not nice to contemplate, whereas one in a teakettle is just a minor annoyance.

TESTS AND SPECIFICATIONS: The most certain test is that of service itself, but this may take a long time, and there may be difficulty in getting accurate reports of service behavior unless the service is performed under impartial engineering auspices. It has been said that "the best test specimen is an actual part loaded to simulate the state of stress encountered in service, but to an aggravated degree if necessary." Sometimes aggravation is not allowable, as in testing for corrosion fatigue.

There are two distinct types of testing. In the first, materials are tested by conventional methods which bear little or no relation to any specific use. These tests merely imply suitability; they do not prove it. The second is simulated service testing, aimed to set up the exact conditions met in a specific type of service and to evaluate materials by their behavior under just those conditions. Such tests go far to prove suitability. "Service," from this point of view, may refer to actual use of a finished part or it may also refer to behavior in fabrication.

. . . a heavy penalty may be involved in laying down a specification that does not include the vital factors or that includes nonvital ones . . .

Purchase specifications and acceptance or rejection thereon of material can only be made straightforward and devoid of ambiguity when they are based on testing methods that give quantitative values, so that no question can arise as to whether a piece is in the "go" or "no-go" classification. Dimensional tolerances bring no disputes; measurement gives the answer. Appraisal of "quality" and suitability is seldom so clear-cut. When attempts are put forth to make it so by incorporation of specified test values for acceptance, the specification maker has a difficult task, for he must include *all* the vital factors, and he *should include no others,* because meaningless tests are nothing but useless expense for which the purchaser pays in the end. When the vendor meets all the purchase specifications, he has a right to payment, even if the material was not the proper one. He may have to produce, to meet an ill-considered specification, material that he knows is not so well fitted for the purchaser's use as the one he would supply were the order placed on the basis of suitability for service.

A heavy penalty may be involved in laying down a specification that does not include the vital factors or that includes nonvital ones. The general specifications for materials seldom go far in envisaging a specific use. Instead they give, in terms of conventional tests, a few attributes that pertain to that general type of material that has been processed in the usual fashion and applied to a variety of uses.

Acceptance Testing: In order that all testing laboratories shall be able to report test values uninfluenced by variations in the method of testing and truly representative of the particular specimen under test, precise directions for calibration of testing equipment, for specimen preparation and for testing procedure are laid down for the conventional tests. Such directions are given in the specifications of the American Society for Testing Materials and summarized in the Handbook of the American Society for Metals and in many textbooks. That a slight error due to an incorrect testing method may cause rejection is apparent since the rules[13] state that, if the specification minimum is 60,500 psi tensile strength, a result of 60,460 psi meets it but 60,450 does not.

There is so natural and so widespread a tendency to appraise materials in terms of simply made, conventional tests that in the description of one (single-blow, notched-bar impact test) the ASTM[14] finds it necessary to incorporate a warning that "the test cannot be generalized and applied quantitatively to other sizes of test specimens or other conditions. . . . Interpretation of the results must be based upon specific research into the correlation with service failures or upon the established limitations of the test."

This particular test, though quantitatively reported in foot-pounds for a given specimen, is not reportable in foot-pounds per square inch because of the size effect in different-sized specimens of identical structure. Twenty-five years ago, Jeffries and Archer[15] pointed out that "the results are not transferable from one form of notched bar to another." Yet German practice still erroneously reports notched-bar values in terms of kilograms per square centimeter.

. . . no one mechanical property but rather a set of mechanical and physical properties are the criteria of suitability for almost any service . . .

Need for Service Testing: That the conventional mechanical tests have limitations and that their interpretation is not always clear and simple is brought out by the following quotation:[16] "In the selection of new materials, devices or processes, all the known facts relating to the physical properties and workability of a proposed new material might be tabulated, studied and analyzed but, not until the experience of working with that material has been gained, can the engineering department safely specify it. Not until new materials have been put to service test in the finished product can they be accepted with assurance."

The service test does not mean that, in order to study design and material for a particular part of a locomotive, the whole locomotive need be operated. Full-scale, simulated service testing of the different parts, properly planned, goes a long way toward revealing the facts.

Conventional tests serve only for a preliminary classification of a new material, because the relationships between the measured properties and the important unmeasured ones are not known and, indeed, close relationships seldom exist. The ordinary tests serve merely to select a candidate for a more extensive study of its behavior in service.

Cassidy[17] remarks, "It is high time that engineers consider the required characteristics of steels for a given application and stop relying upon nominal and arbitrary factors hallowed by long use."

In 1943 Herzig[18] said: "In the past a great deal of emphasis has been placed on physical tests which were faithfully performed because we knew so well how to perform them, rather than because those tests precisely described the fitness of material for service. The new viewpoint focuses attention on fundamental characteristics and not on tests whose relation to performance is obscure at best."

Recognition of Service Testing: The ASTM has added to its older activities relative to conventional tests of materials others on simulated service testing and held a symposium[19] on testing of parts and assemblies.

Discussing a case where accumulated experience is limited, Finch[20] says: "The problem of determining operating stresses still awaits satisfactory solution. In the meantime, the turbojet designer, if he is to keep pace with the metallurgist, must of necessity acquire a knowledge of all the properties of the material, including behavior under vibration or stress or temperature variation, heat shock, notch sensitivity, corrosion and erosion by hot gases, ductility, and stability. The designer who looks on the endurance test (of the completed engine) as the real beginning of development will have the best chance of remaining on fairly solid ground."

. . . full-scale, simulated service testing . . . goes a long way toward revealing the facts . . .

As a result of the paucity of exact knowledge in the field of jet engines, it has been commented that the parts are usually "overalloyed and underdesigned."

LIMITATIONS SET BY CONVENTIONAL TESTS: Rockets may need to function for only a few seconds. Bonner[21] points out that the design of a rocket chamber is based on yield strength since no appreciable relative distortion of parts can be allowed for ballistic reasons, and also because it is necessary, for safety's sake, to apply a hydrostatic test to the chamber before filling. But the low yield strength of austenitic stainless steel in the conventional tension or the hydrostatic test rules out this otherwise promising material although its yield strength is notably higher at the strain rate actually imposed in service. But until a "hydrodynamic" proof test can be devised to replace the slowly applied hydraulic test, the designer cannot make use of the increase in yield and tensile strength displayed under actual service conditions.

Thus, the exact service in view is the ultimate criterion. Choice of metals and the fitting together of production methods and the metals suitable for those methods have always to meet this criterion.

. . . purchase specifications and acceptance or rejection . . . can only be straightforward and devoid of ambiguity when they are based on testing methods that give quantitative values . . .

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Design Factors for Stress Concentration

Part 3—Fillets in Bending

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TERMINOLOGY and general calculation methods were given in Part 1 of this series, published in the February issue. Stress-concentration factors given by the graphs on the following pages can be applied in the design for bending of filleted members such as those shown in ***Fig.*** **12**. The dimensioned example in ***Fig.*** **13** will be used to demonstrate one of the calculation procedures.

Curves of ***Fig.*** **14** for a flat bar with shoulder fillet are based on the photoelastic tests of Leven and Hartman.[1] ***Figs.*** **15** and **16**, for a shaft with shoulder fillet, are based on ***Fig.*** **14** and on the notched bar and shaft values plotted in ***Figs.*** **2, 3** and **4** of Part 1. Values for notched and filleted cases in two and three-dimensions have been related by the simple proportionality of $K_t - 1$ factors. Thus,

$$K_{t3f} = 1 + (K_{t2f} - 1)\left(\frac{K_{t3g} - 1}{K_{t2g} - 1}\right) \quad \ldots\ldots\ldots\ldots (1)$$

where subscripts 2 and 3 denote two and three-dimensional cases and subscripts *f* and *g*, fillets and grooves.

Factors given in ***Figs.*** **14, 15** and **16** apply when the large diameter, *D*, extends a relatively great distance from the shoulder. Frequently in design a member with a short shoulder length, *L*, is encountered, as in ***Fig.*** **17**. Variation of K_t with L/D for D/d values of 3, 2 and 1.25 have been published.[1] Since these three ratios yield curve families of similar shape, only the one for $D/d = 2$ (***Fig.*** **17**) is shown. This can be adapted for other D/d values by use of the following formula:

$$K_{tL} = 1 + (K_t - 1)\left(\frac{K_{tb} - 1}{K_{ta} - 1}\right) \quad \ldots\ldots\ldots\ldots (2)$$

where K_{tL} is the required factor, corrected for shoulder width; K_t is the factor to be corrected from ***Figs.*** **14, 15** or **16** for long shoulder; K_{ta} is the factor for $L/D = 2$ from ***Fig.*** **17**; K_{tb} is the factor for desired L/D from ***Fig.*** **17**. As mentioned in the preceding article of this series (March issue) this same method can be used in design for notched and grooved members.

EXAMPLE: The outlined method can be used to estimate the fatigue strength of the member shown in ***Fig.*** **13**. Assume that the material is heat-treated steel with a tensile strength of 140,000 psi. If the endurance limit is known, it can be used in the calculations. If not, it can be estimated at half the tensile strength, or 70,000 psi. The following ratios are obtained: $D/d = 1.10$; $r/d = 0.025$; $L/D = 0.136$. From ***Fig.*** **16**, $K_t = 2.07$. From ***Fig.*** **17**, $K_{tb} = 2.12$ and $K_{ta} = 2.86$. By substitution of these values in Equation 2, $K_{tL} = 1.65$. To take account of notch sensitivity, obtain *q* from ***Fig.*** **5** (Part 1, February). For 1/32-inch radius, $q = 0.90$. Substituting in the fatigue-notch factor equation (Part 1), $K_f = 1 + q(K_{tL} - 1) = 1.58$. The estimated fatigue strength is $S_f = 70{,}000/1.58 = 44{,}000$ psi.

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Curve sheets appearing in this article together with additional design data will appear in a forthcoming book to be published by John Wiley & Sons Inc., New York.

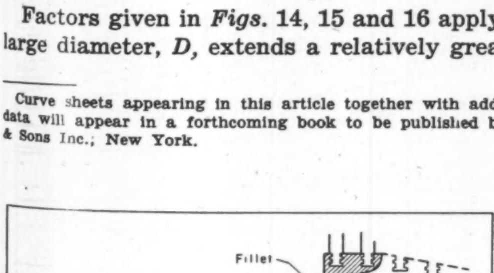


Fig. 12—Examples of filleted members. A crankshaft is shown at *(a)*, turbine shaft at *(b)*

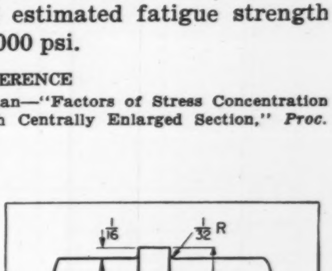


Fig. 13—Example used to show how factors of *Fig.* 17 for $D/d = 2$ can be extended to other D/d values

Data Sheet

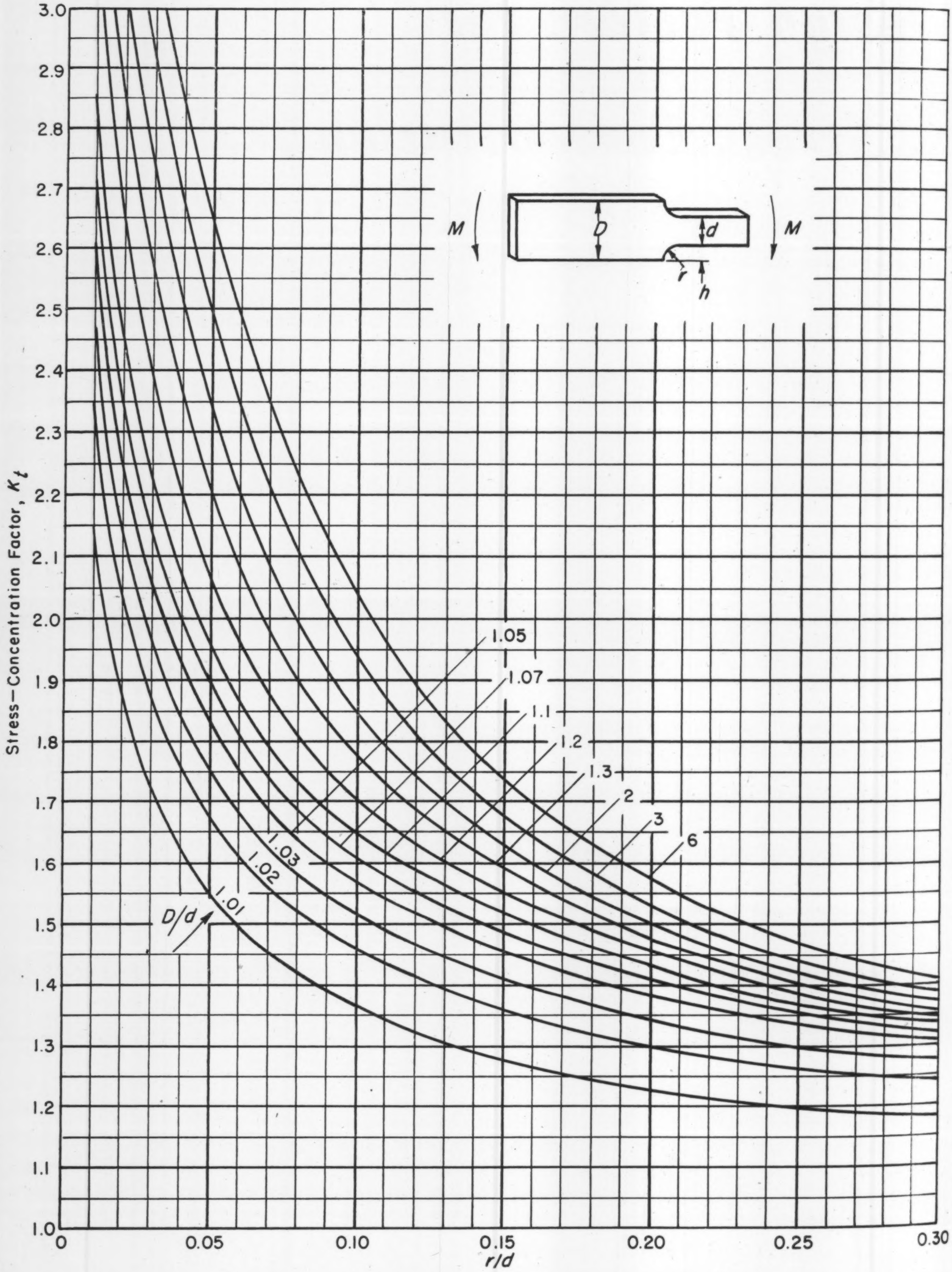


Fig. 14—Stress-concentration factor, K_t, for a flat bar with shoulder fillet in bending. Curves represent values determined photoelastically by Leven and Hartman

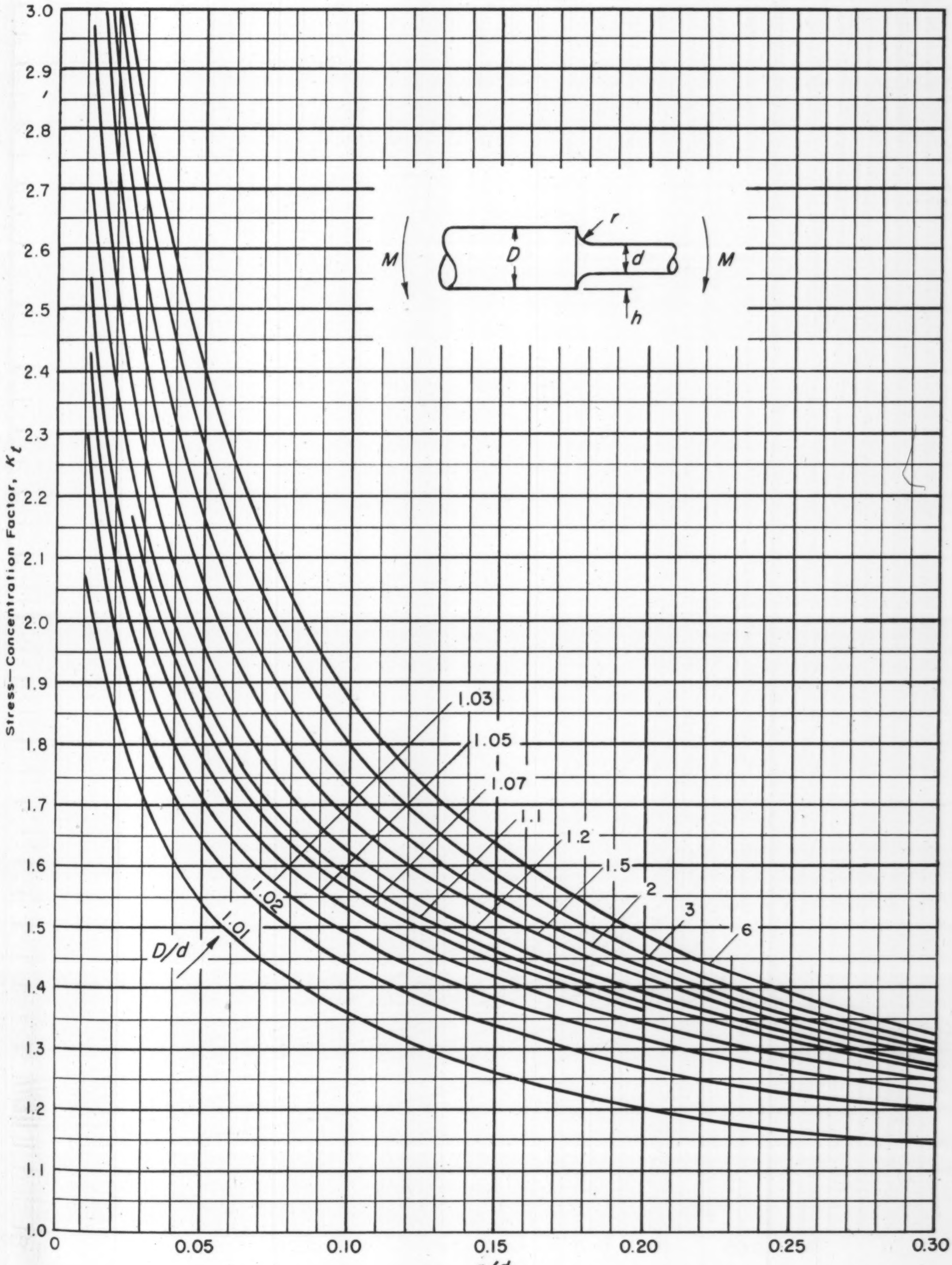


Fig. 15—Stress-concentration factor, K_t, for a shaft with shoulder fillet in bending. Curves are proportioned from *Figs.* 2 and 3, Part 1, and *Fig.* 14

Data Sheet

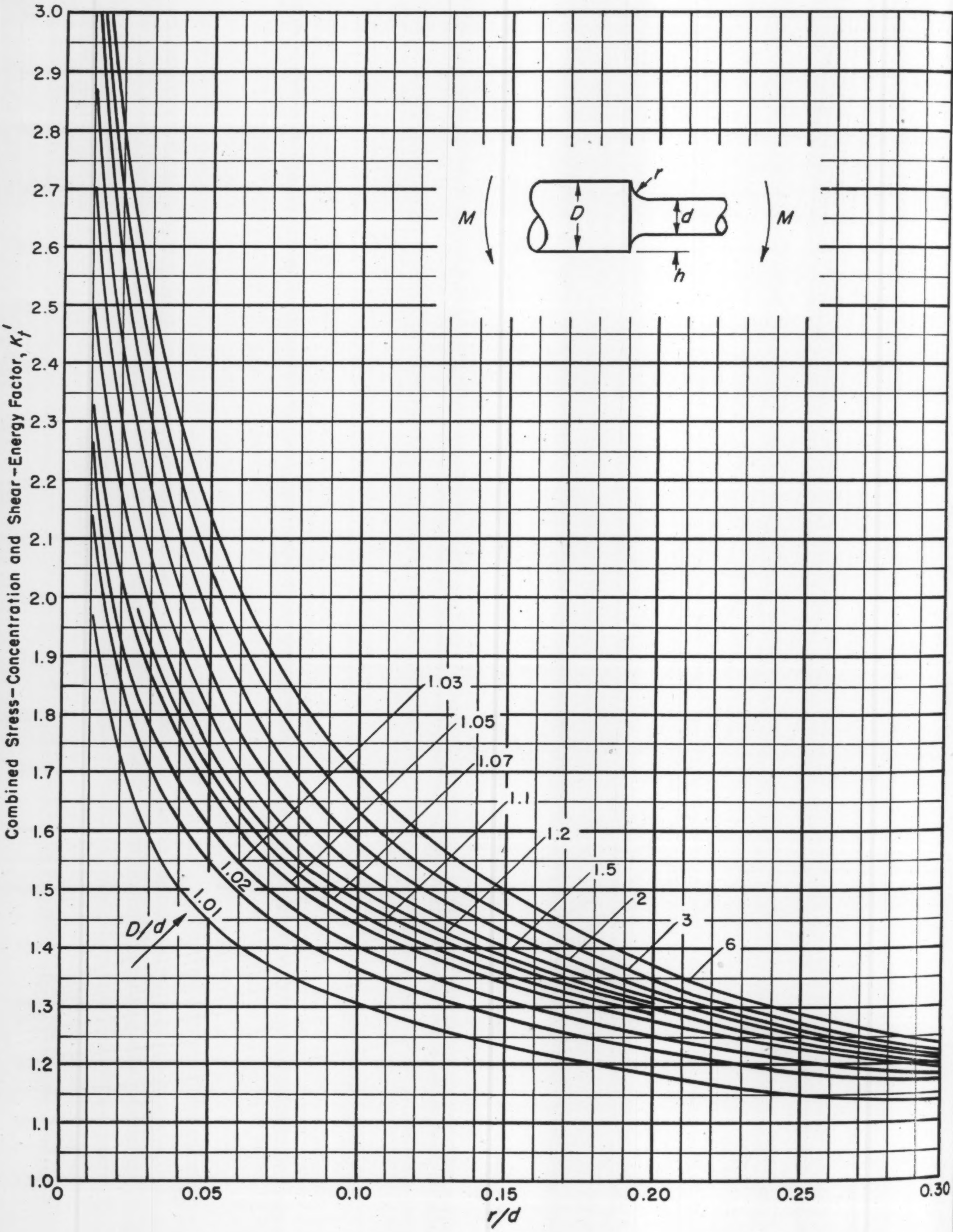


Fig. 16—Combined stress-concentration and shear-energy factor, K_t', for a shaft with shoulder fillet in bending. Factor $K_t' = mK_t$ where m = factor for shear-energy theory of failure

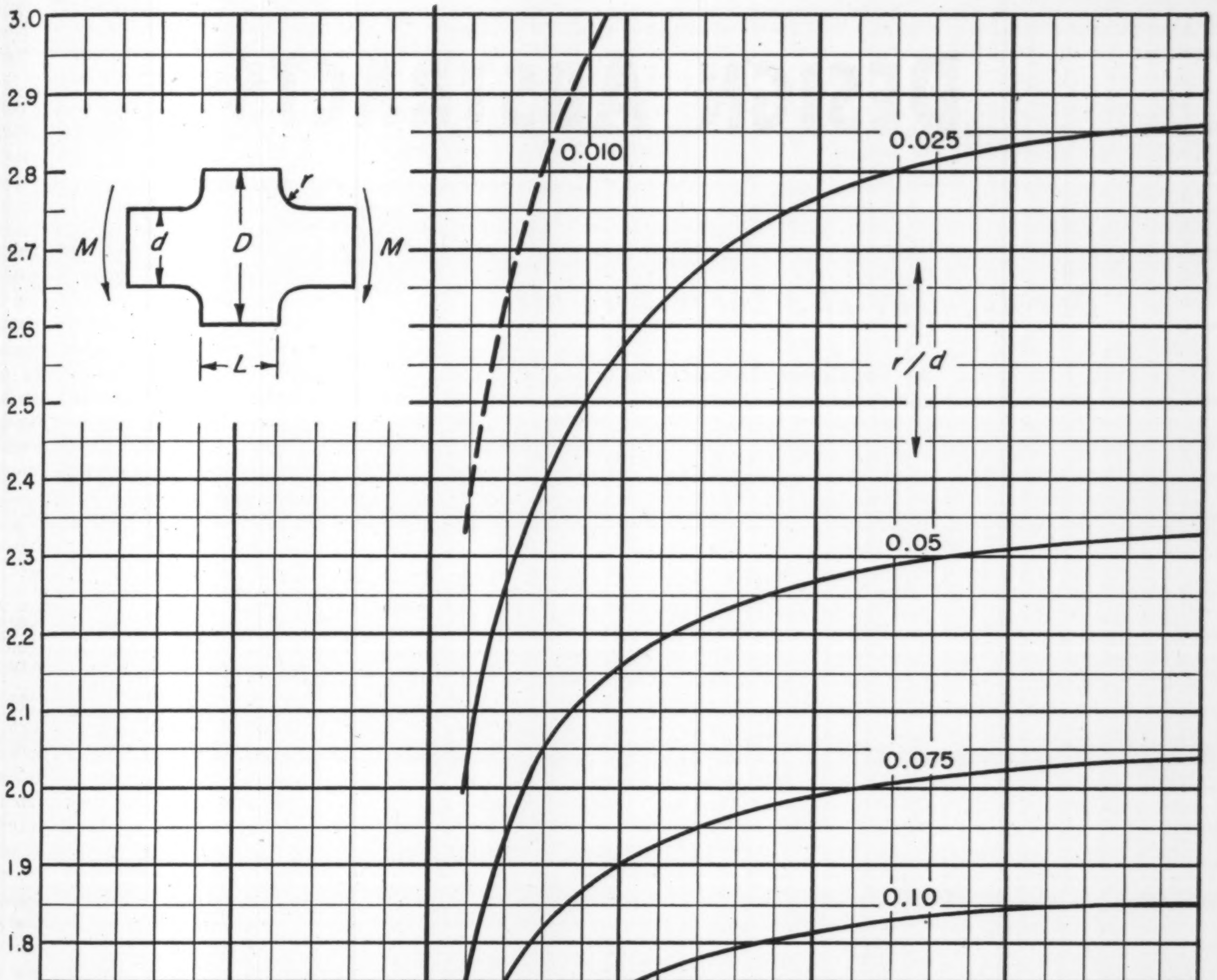


Fig. 17—Stress-concentration factor, K_t, for filleted bars with short shoulder lengths in bending. Restricted to $D/d=2$, these factors can be extended to other ratios by use of Equation 2. Curves represent values determined photoelastically by Leven and Hartman

DESIGN ABSTRACTS

Development of a Large Aircraft

. . . the Lockheed *Constitution*

By W. M. Hawkins Jr. and R. L. Thoren

DURING the original design studies of the *Constitution, Fig.* 1, it was immediately apparent that rapid developments in equipment, airplane design, and power plant conception could easily obsolete the design unless every effort was made to incorporate these improvements as the design progressed and to provide for later incorporation of new power plants if they became available.

The original requirements for the *Constitution* resulted from the combined efforts of the United States Navy, Pan American Airways, Inc., and the Lockheed Corporation. Many hours were spent in the careful determination of basic design directives which resulted in the following outline characteristics: (1) Four-engine safety in accessory and system components as well as in the basic power plants; (2) Full pressurization for cargo and passenger space for flight at 25,000 feet; (3) Maximum in-flight access to vital mechanical components and airplane systems to permit air repairs which would contribute to vastly improved regularity; (4) Full dependence on a flight engineer to relieve the pilots from tiring routine responsibilities and to make possible careful enroute trouble shooting to assist ground maintenance and permit rapid turn around; (5) Maximum utility of space to allow either passengers or cargo to be carried; (6) Flying characteristics which would be equal to or better than the best current transports, and stalling speed which would permit the use of average airports despite airplane size; (7) All-weather equipment, including complete wing and tail heat anti-icing; (8) Maintenance simplicity which would surpass that of any other four-engine transport; (9) Manufacturing simplicity which would insure a reasonable production price; (10) Design flexibility that would permit larger and more advanced power plants to be installed when they were available.

GENERAL ARRANGEMENT: Many general airplane configuration ideas were studied, including buried engines, all-wing designs, pusher propellers, and tail-first canard arrangements. None of these ideas offered any substantial advantages and it was firmly concluded that only a conventional airplane design would permit early development and easy introduction into service. Since the size of the airplane was unconventional, this decision aided considerably in assuring both the Lockheed Company and the Bureau of Aeronautics that the development could be concluded successfully.

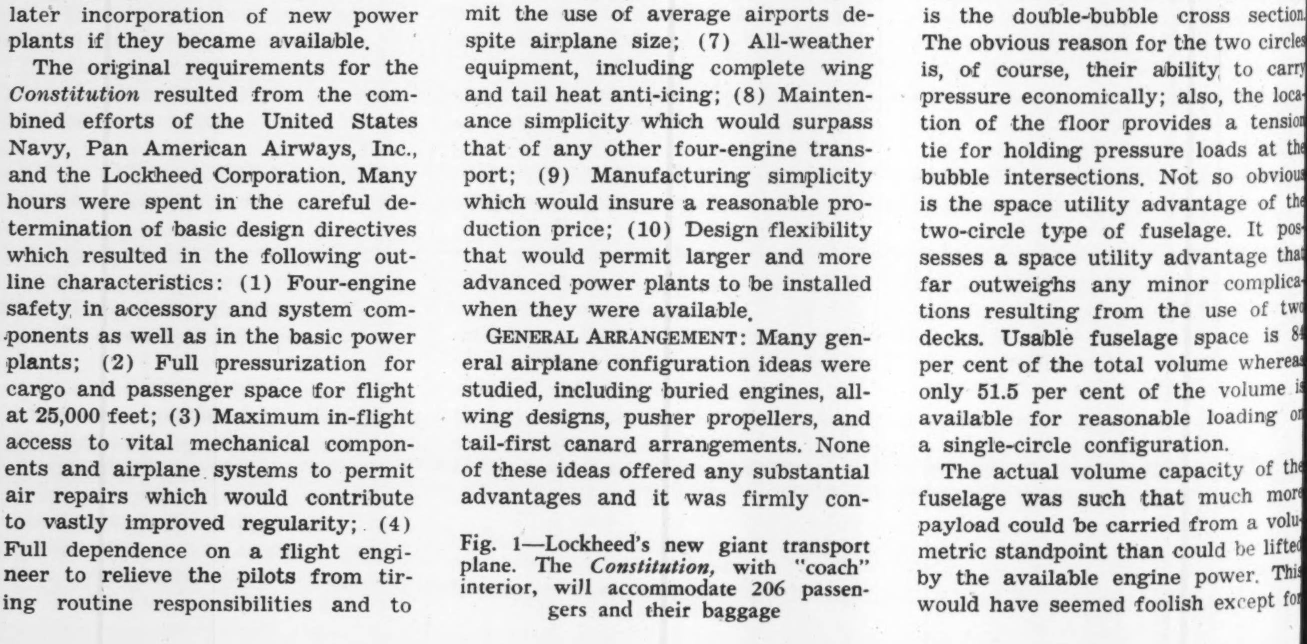
Some engineering data from the final design are as follows:

Wing span	189 ft
Overall length	156 ft
Total fuel tank capacity	9600 gal
Design level flight speed	260 mph
Take-off power and speed	3500 hp/2700 rpm
Normal power and speed	2650 hp/2550 rpm
Propeller diameter (4-blade)	16 ft, 8 in.
Design cruise altitude	25,000 ft
Empty weight	116,275 lb
Maximum take-off gross weight	184,000 lb

Interior Arrangement: Though far from unique, the most noteworthy feature of the *Constitution* fuselage is the double-bubble cross section. The obvious reason for the two circles is, of course, their ability to carry pressure economically; also, the location of the floor provides a tension tie for holding pressure loads at the bubble intersections. Not so obvious is the space utility advantage of the two-circle type of fuselage. It possesses a space utility advantage that far outweighs any minor complications resulting from the use of two decks. Usable fuselage space is 84 per cent of the total volume whereas only 51.5 per cent of the volume is available for reasonable loading on a single-circle configuration.

The actual volume capacity of the fuselage was such that much more payload could be carried from a volumetric standpoint than could be lifted by the available engine power. This would have seemed foolish except for

Fig. 1—Lockheed's new giant transport plane. The *Constitution,* with "coach" interior, will accommodate 206 passengers and their baggage



he fact that complete flexibility could hus be attained in selecting loads of arying density without completely onverting the airplane and removing assenger seats. A further reason for ccepting the obvious weight penalty n a large-volume fuselage was that olume would be available for the igher payload capabilities of adanced power plants.

The use of the *Constitution* fuseage for all passenger commercial arangements leads to many unique ossibilities. One-hundred sixty-eight assengers may be carried in standrd airline comfort and it has been etermined that 206 passengers can e carried in what is now called oach type seating. In an entirely ifferent arrangement, 52 passengers an be carried with full-size berths or 28 and stateroom facilities for 24.

Cargo handling is extremely conenient in all passenger versions beause of the large volume between he forward stair well and the wing, nd the large space within the wing tself. This total volume, easily eached by large doors on each side f the fuselage, is sufficient to carry 10,640 pounds of baggage or cargo, ore than adequate even for a coach nterior carrying 206 passengers with 40 pounds of baggage each.

Extensive Mock-Up Studies

As shown in *Fig.* 2, a complete wooden full-scale mock-up of the fuselage was constructed, including a left-hand inner wing containing the main landing gear and nacelles. The interior of this mock-up was used very extensively for developing the arrangement of all sections within the fuselage. Evacuation tests were run on the mock-up and details of the emergency exits were revised so as to provide efficient egress from the airplane whether it be on its wheels, fuselage belly, or in the extreme condition of emergency water ditching operation.

Crew Arrangement: In accordance with recommendations of the Lockheed Company and Pan American Airways, the Bureau of Aeronautics permitted an extremely complete investigation of the crew facilities and arrangement in the airplane mock-up program of the *Constitution*.

In the early days of the conception of these crew requirements, the advantage of using a flight engineer was only beginning to be appreciated but it had already become apparent that one of the more important functions of this officer was the constant in-flight trouble shooting of the power plants and equipment systems. This factor, coupled with the accessibility of almost all the system components in flight, further augmented by the addition of the complete pressure and air conditioning systems, immediately suggested the addition of the assistant flight engineer's station.

The navigator and radio stations as installed in the airplane were relatively conventional, being dictated primarily by the navigation equipment then available. A periscopic sextant was considered, but the development time appeared to be prohibitive, so a normal astrodome was installed with a safety harness for the navigator.

The entire crew station was developed through many careful hours of mock-up study and two major mock-up conferences attended by both military services and by Pan American personnel. *Fig.* 3 shows the actual flight engineer's station. Motion studies were attempted by experienced flight engineers and mechanics studying operational problems and rearranging equipment so as to provide utmost accessibility and smooth co-ordination.

POWER PLANT DEVELOPMENT: The design history of the *Constitution* power plant installation included some new concepts which were dropped due to the long development time required but which may be of interest. The first of these was the steam-driven engine supercharger. A complete design for this supercharger was well under way when an exhaust-driven centrifugal type was offered which promised to give satisfactory, though not comparable, results without requiring the great development time and expense.

The turbo supercharger finally used was also a new concept in that its design did not contemplate supercharging any more than maximum permissible cruise power at 25,000 ft. This reduction in normal supercharging capacity permitted the use of a smaller unit, smaller intercoolers, and smaller installed frontal area of the nacelle. The complete power egg, which was identical for all four locations on the airplane, had a frontal area of only 27 sq ft. This compactness, which was believed to be an aerodynamic accomplishment, actually became a detriment since the original estimated air flow requirements for cooling the engines were eventually doubled and sufficient cool-

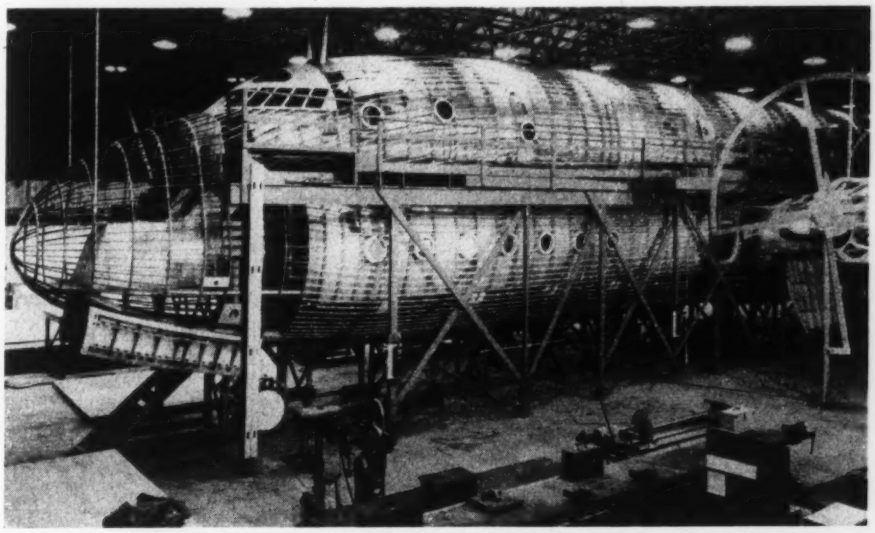
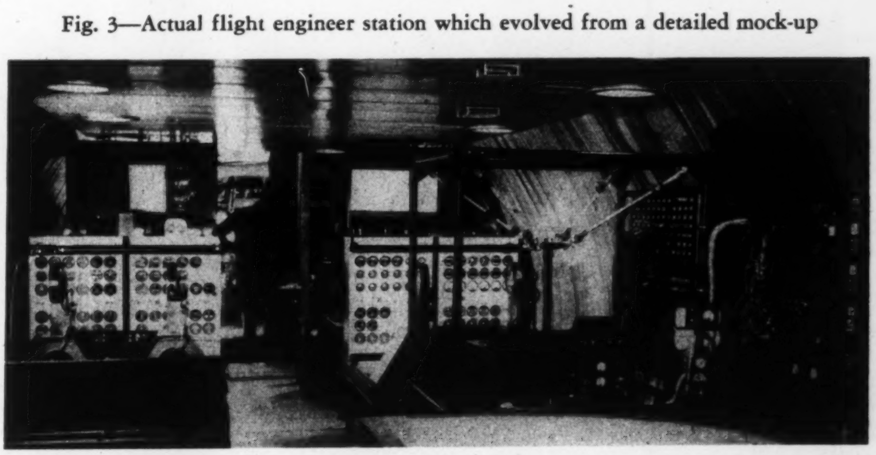


Fig. 2—Fuselage mock-up used in development of interior arrangement

Fig. 3—Actual flight engineer station which evolved from a detailed mock-up



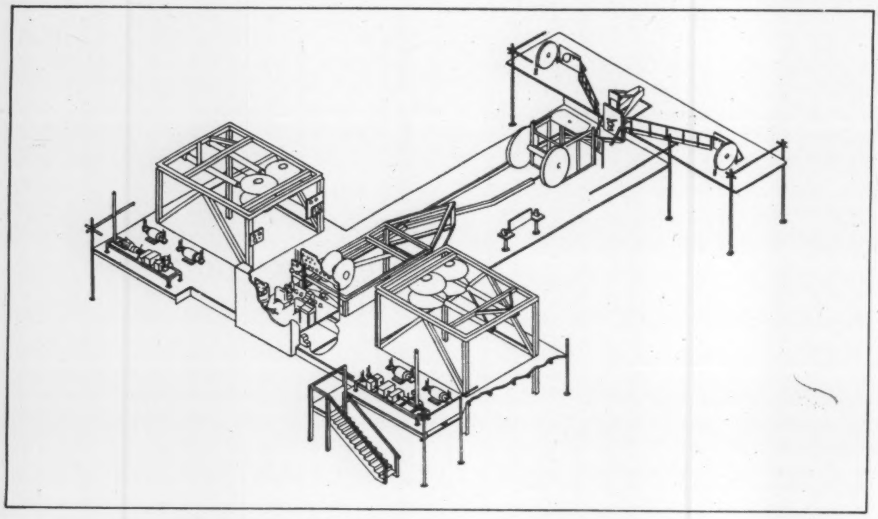


Fig. 4—Mock-up employed for development and checking of hydraulic system

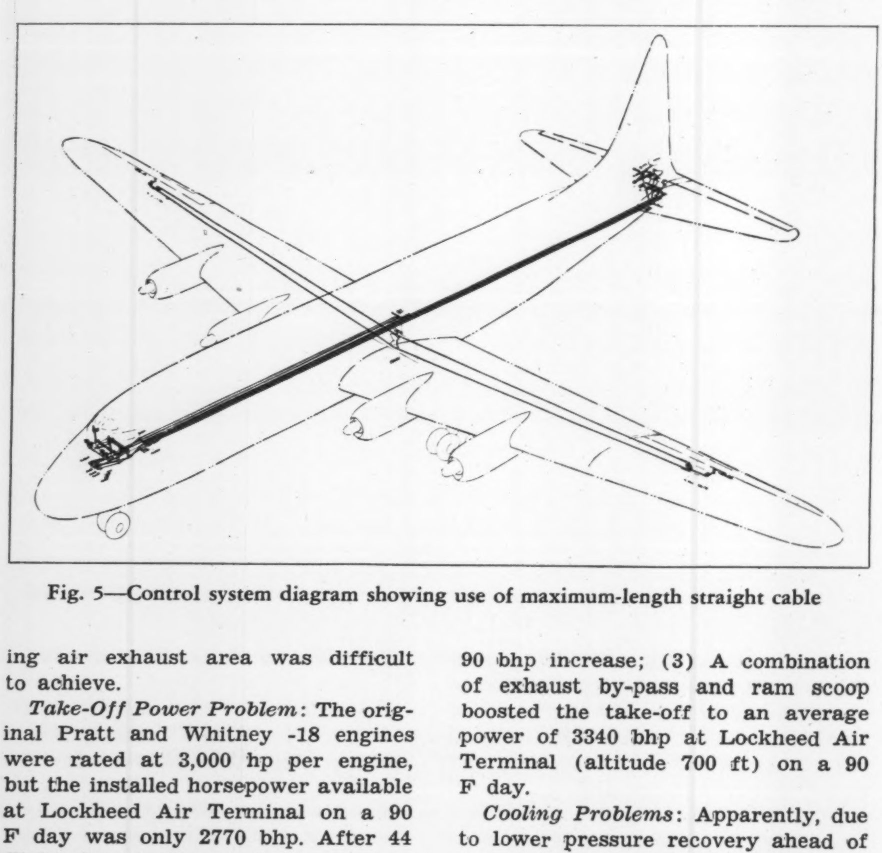


Fig. 5—Control system diagram showing use of maximum-length straight cable

ing air exhaust area was difficult to achieve.

Take-Off Power Problem: The original Pratt and Whitney -18 engines were rated at 3,000 hp per engine, but the installed horsepower available at Lockheed Air Terminal on a 90 F day was only 2770 bhp. After 44 flight hours, the engines were replaced by -22 engines, which were rated at 3500 bhp for take-off with water injection and grade 115/145 fuel. On a 90 F day, however, the maximum take-off power was still only 2900 bhp. The following changes were made to increase the power: (1) A ram scoop was installed which increased the take-off power available to 3095 hp. With 0.5-in. Hg ram, it was increased further to 3170 bhp; (2) An exhaust system by-pass valve was installed to by-pass the turbo supercharger during take-off, which reduced the back pressure to 5-7 in. Hg above ambient, resulting in a 60 to 90 bhp increase; (3) A combination of exhaust by-pass and ram scoop boosted the take-off to an average power of 3340 bhp at Lockheed Air Terminal (altitude 700 ft) on a 90 F day.

Cooling Problems: Apparently, due to lower pressure recovery ahead of the engine, considerably greater cooling air flow of the engine than predicted, and exit losses higher than predicted, the cooling was far short of specification requirements. Numerous changes were made and, finally, an acceptable power plant resulted. The major changes were as follows: (1) Exit area was increased 60 per cent by modifying supporting structure for the cowl and eliminating exhaust collector and exhaust stack shrouds; (2) Cowl entrance area was increased considerably by cutting away the lower duct lip; (3) A special chute was provided to exhaust air from behind the two hottest cylinders with an appropriate clam shell at the chute exit.

SYSTEMS DEVELOPMENT: Since the size and complexity of the *Constitution* were unusual, and since the expense and risk of flight testing such a large airplane with relatively unproved components were not reasonable, a complete systems development program was instituted to insure before flight that the major airplane operating units would function satisfactorily. This type of preflight system checkout, as illustrated by the mock-up in *Fig.* 4, had been pioneered in the development of the Lockheed *Constellation* and its value more than affirmed.

Electrical System: A load analysis of all the requirements that could simultaneously be placed on the ship's electrical system revealed an amazing power requirement—so much so that the total electrical potential available from the generating equipment on the airplane is in excess of that required by 20 average homes at peak load.

Constant Speed Drive a Problem

The Air Force had already committed itself to the use of a 208 volt, 3-phase, 400 cycle a-c system on a large airplane and it was felt to be advisable to follow along in the same pattern. The very heart of a successful a-c electrical system is, of course, a constant speed device for driving the alternators. All units under development were based upon the same general philosophy of a hydraulic pump and motor arrangement with either pump or motor flow being regulated so as to result in constant output speed throughout the entire engine speed range. Before the development and testing work on the constant speed drives had progressed very far, it became apparent that they were all in serious trouble and not behaving as predicted. Again it seemed possible that the problem could be solved but to be conservative, the Lockheed Company dug into the details of a possible retreat in the event that time did not permit a satisfactory solution to the constant speed problem. This foresight paid rich dividends later.

The original concept of the electrical system had to be completely changed prior to the first flight of the prototype because the constant speed drive and alternator had to be abandoned. The electrical system was redesigned to make use of 120-v d-c generator system. One of these generators was installed on the prototype to obtain service experience. When the second airplane was flown, it was equipped with the 120-v d-c system.

Control System: In establishing the

basic flight control system to be used in the *Constitution,* two factors were given equal importance: safety and pilot's control forces. Following the successful experiences already established by Lockheed on the *Constellation* and *P*-38, the basic philosophy of using hydraulic boost was again adopted. A single hydraulic system was obviously not the answer and, perhaps, multiple circumstances could develop which might cause two systems to fail simultaneously. Therefore three completely independent systems were selected. The location of pumps on the engines was so arranged that any two of the three systems could be completely inoperative, leaving horizontal and either vertical or lateral control for the pilot at all times. As actually determined by flight testing, all four engines could be dead and sufficient power would be supplied by one windmilling propeller to provide suitable control for landing.

One extremely important point in connection with the success of a hydraulic booster system is the measured value of the control system friction. The Lockheed boost system retains, as a basic part of the design philosophy, the normal pilot "feel". This is a true value arising out of the arrangement of linkages in the boost system which translates pilot forces into applied forces at the control surface and, conversely, the air loads on the surfaces react directly to the control points in the cockpit. The ability of this reaction to take place and permit surfaces to neutralize when no stick forces are applied is in direct proportion to the value of the control cable friction.

The most obvious way to reduce cable friction forces is to use straight cable runs so that the friction produced by changing direction around pulleys can be eliminated. The deep upper deck floor structure on the *Constitution* proved invaluable in this regard as shown in *Fig.* 5. Perfectly straight cable runs over extremely long distances are made possible by running the control cables through this structure. As shown on *Fig.* 5, the control system would appear to have been the governing criterion in the airplane configuration since no airplane component has been permitted to interfere with straight control cable paths.

Three Hydraulic Systems Used

HYDRAULIC SYSTEM: As already stated in connection with the description of the flight control system, the *Constitution* hydraulic system is actually three separate systems. A 3,000-psi pressure is used throughout except for the brakes which operate through a pressure reducer.

Since the power requirements under peak load conditions for controls, flaps, landing gear actuation, etc., were so high, the number of hydraulic pumps needed to do the job is very large. No large pumps were developed and available to help alleviate this problem at the time so it was necessary to install three pumps on each engine. Had large capacity pumps been available, they could have helped reduce the number to perhaps eight instead of twelve. However, there are certain indirect advantages to having the smaller pumps since, like multiple engines, they provide an added degree of safety should one fail.

A thirteenth pump is installed in the fuselage, powered by two electric motors geared together. This additional source of power has multiple uses. While the airplane is parked or is being towed, it provides hydraulic pressure using the ship's batteries or a ground cart for electrical energy to permit operation of the brakes and nose wheel steering. This electrically driven pump may also be used to check out the control system booster and flap system on the ground as part of an inspection or preflight check.

All valves used throughout the hydraulic system are electrically actuated and have a manual over-ride lever to permit hand operation in the event of electrical power failure. Electrical operation of valves has a big advantage from many aspects. It is obviously simple to route wiring from switches to valve actuators when compared to cable actuation. On such systems as the main and nose landing gears, the problem of sequencing door operation is much easier when precision switches can be used. The small electric motors used to operate the valves are 400 cycle a-c types and have no brushes; thus altitude problems usually associated with electric motors having brushes are nonexistent. A standard motor gear box unit was developed and is used throughout on all types of valves, regardless of function, thus simplifying the spares problem.

Extensive Tests Worthwhile

The very extensive laboratory tests of the complete hydraulic system, including the surface control power boosters, landing gear, etc., *Fig.* 4, were demonstrated to be worth-while by the absence of hydraulic system problems during the flight test program. One failure that showed up in the flight test program that was not uncovered by the laboratory tests was fatigue failure of 24S-T lines having small bend radii. This was undoubtedly due to the absence of vibration in the laboratory tests.

Fuel System: The first problem to be faced in designing the fuel system in any airplane is the location of the fuel tanks. Apart from a fuel tank arrangement consisting of one large tank with all engines feeding from it, the next simplest appeared to be one fuel tank for each engine. It is

(*Continued on Page* 206)

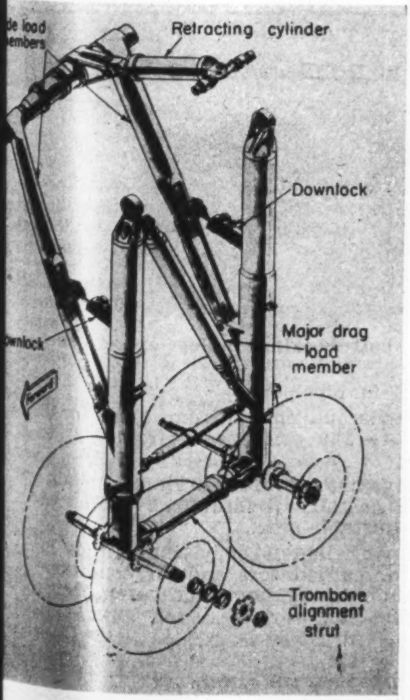


Fig. 6—Left—Main landing gear assembly

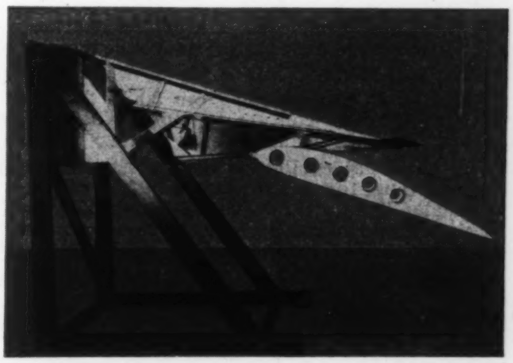


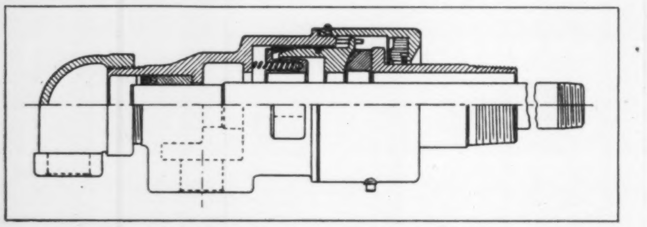
Fig. 7 — Right — Wing flap mechanism mock-up

NEW PARTS AND MATERIALS

. . . presented in quick-reference data sheet form for the convenience of the reader. For additional information on these new developments, see Page 185

Revolving Joint 1

Rotherm Engineering Co. Inc., 4911 *W. Irving Park Rd., Chicago* 41, *Ill.*



Style: Two-way with syphon tube; self-contained

Size: ½ to 5-in. pipe inclusive

Service: Steam at pressures to 150 psi max and temperatures from −65 to 500 F.

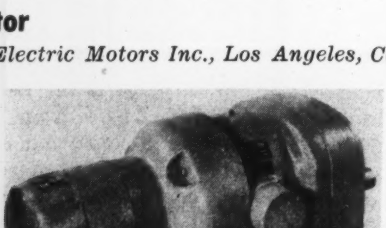
Design: Revolving element rotates on face of flat carbon ring which also has opposite spherical face to correct for misalignment; gland sealed by spring-loaded Teflon wedge ring and piston ring; syphon pipe rotates in carbon bushing and is sealed with chevron packings

Application: For piping connections to steam heated rolls, calenders, etc., where it is desired to have steam entry and condensate removal at same point.

For more data circle MD 1, Page 185

Gearmotor 2

Sterling Electric Motors Inc., Los Angeles, Calif.



Designation: Slo-Speed

Style: Totally enclosed, fan cooled gearmotor with motor mounted disk brake; double reduction.

Size: 2 to 15 hp

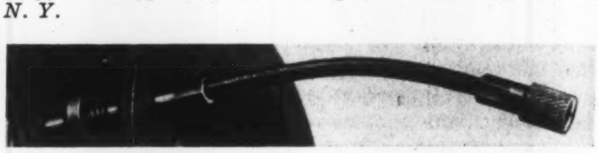
Service: AGMA speeds from 30 to 280 rpm inclusive; atmospheres containing nonexplosive dust, vapors and other injurious foreign matter

Design: Dual cooling system with internal and external fans for motor and housing cooling; labyrinth seals; life-time lubricated heavy-duty ball bearings; herringbone rotor; mounts in any position without modification; brake can be supplied for either stopping or holding

For more data circle MD 2, Page 185

Flexible Shaft Assembly 3

Kupfrian Mfg. Co., 534 *Prospect Ave., Binghamton, N. Y.*



Style: Power drive and remote control with variety of standard fittings to suit; casings—single flat wire with or without vinyl cover, 2 and 4-wire, squared-locked or fully interlocked, and braided types

Size and Service: Right and lefthand (power end), clockwise or counterclockwise rotation; shaft diameters 0.130, 0.150 and 0.187 (power), 0.130, 0.150, 0.187 and 0.250 (remote); max torque 0.5 through 6 lb-in. (power), 1½ through 40 (remote)

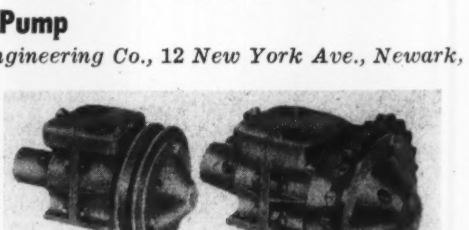
Design: Shaft core helically wrapped wires of galvanized high-carbon steel, bronze, Monel, or stainless steels; better strength and efficiency with high-carbon steel, nonmagnetic and corrosion-resistant properties with other metals; vinyl and fully interlocked casing for water tightness and corrosion resistance, braided types for stretch resistance

Application: For tachometer drives, television receiver controls, transmitter controls, misalignment connections, etc., where it is desired to transmit power or actuating force without gears, joints, etc.

For more data circle MD 3, Page 185

Fluid Pump 4

Eco Engineering Co., 12 *New York Ave., Newark, N. J.*



Style: Gear pump; ball bearing pulley or sprocket drive; reversible

Size: ¼, ⅜, ½, and ¾-in. pipe ports

Service: Liquids or viscous fluids from 1/10 to 19 gpm at pressures to 150 psi; speeds from 300 to 3400 rpm

Design: Pump housings naval bronze forgings or stainless steel precision castings; hydraulically balanced built-in by pass; adjustable base

Application: For moving liquids or viscous fluids in systems such as for carbonators and air conditioning, spraying, steam cleaning, home hot water, chemical handling, marine, etc.

For more data circle MD 4, Page 185

JOHNSON BRONZE

SLEEVE BEARING DATA

Bearing DESIGN

SLEEVE BEARING DATA

Clearances

INTERNAL COMBUSTION ENGINE BEARINGS

Dia. of Crankshaft Journal or Crankpin	*Oil Clearance between shaft and bearing on diameter*	*Crankshaft End Clearance*
2'' to 2¾''	.0015 ± .001	.004 to .006
$2\frac{13}{16}$'' to 3½''	.0025	.006 to .008
$3\frac{9}{16}$'' to 3¾''	.003	.008 to .010
3⅞''	.0035	.008 to .010
4''	.004	.008 to .010

*This data computed on the use of white or babbitt metals.

OIL CLEARANCE in sleeve-type bearings is that difference in size between the diameter of the shaft and the inside diameter of the bearing. This space accommodates the lubricant, permits the formation of a protective oil film preventing metal-to-metal contact when in operation and allows for expansion due to heat. Bearing performance, bearing life and machine operation are all greatly affected by oil clearances determined through correct dimensions of shaft and bearing.

It is quite impossible to set hard and fast rules for all applications. So many factors go into the successful operation of bearings that each should be given individual study and clearance data decided from the findings. However, certain general standards can be used as a guide towards correct oil clearances.

The above chart lists the average oil clearances most widely used for internal combustion engine applications. This applies to units in which a force feed, pressure lubrication system is used. The vertical clearance is generally maintained to low limits whereas higher clearance is maintained at split line, accomplished by eccentric bore or reliefs at parting line. For splash lubricated bearings, where the engine speed is less than 2000 R. P. M., the minimum oil clearance will be somewhat larger, varying from .0002 to .0006 per inch of shaft diameter.

BEARING CLEARANCES IN INDUSTRIAL APPLICATIONS

CLASS OF BEARING	*Running Clearance, Thousandths of an inch, for shaft dia. under*				
	½''	1''	2''	3½''	5½''
Precision Spindle Practice—Hardened & ground spindle lapped into the bronze bushing. Below 500 ft./Min. & 500#/Sq. In.	.00025 to .0075	.00075 to 0015.	.0015 to .0025	.0025 to .0035	.0035 to .005
Precision spindle practice—Hardened & Ground spindle lapped into bronze bushing. Above 500 ft./Min. & 500#/Sq. in.	.0005 to .001	.001 to .002	.002 to .003	.003 to .0045	.0045 to .0065
Electric Motor & Generator Practice—Ground Journal in broached or reamed bronze bushing or reamed Babbitt bushing	.0005 to .0015	.001 to .002	.0015 to .0035	.002 to .004	.003 to .006
General Machine Practice (Continuous rotating motion)—Turned steel or cold rolled steel Journals in bored & reamed bronze or poured & reamed babbitt bushings	.002 to .004	.0025 to .0045	.003 to .005	.004 to .007	.005 to .008
General Machine Practice (Oscillating Motion)—Journal & Bearing material as above	.0025 to .0045	.0025 to .0045	.003 to .005	.004 to .007	.005 to .008
Rough Machine Practice—Turned steel or cold-rolled steel Journals in Poured babbitt bearings	.003 to .006	.005 to .009	.008 to .012	.011 to .016	.014 to .020

Ordinary industrial applications can be governed by general clearance practice—as listed below. We have found, through more than 40 years exclusive bearing manufacturing experience, that the majority of applications can be so classified. The tolerance range, as shown by the chart, provides ample room for the formation of a protective lubricating film. In certain specific applications, such as some types of machine tools engaged in producing very precise parts, clearances must be held to very close limits.

There is one sure way of removing doubt concerning tolerances and oil clearances. Call in a Johnson Bronze Engineer. We are interested in giving you bearings that will suit your applications—bearings that will deliver greater performance and longer bearing life. Our men are trained in all phases of bearing practice. We offer their services to bearing users without obligation of any kind.

This bearing data sheet is but one of a series. You can get the complete set by writing to—

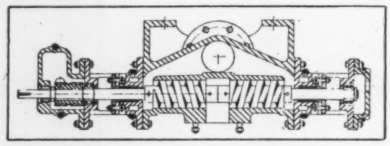
Johnson Bronze

SLEEVE BEARING HEADQUARTERS
525 S. MILL ST. • NEW CASTLE, PENNA.

NEW PARTS AND MATERIALS

Screw Pump 5

Sier-Bath Gear & Pump Co., 9252 Hudson Blvd., N. Bergen, N. J.



Style: External gear and bearing bracket type, vertical or horizontal

Size: 1 to 700 gpm

Service: Positive displacement of nonlubricating liquids of all viscosities; speeds to 1800 rpm direct-connected; discharge pressures to 1000 psi

Design: Single-point supported—external gear and bearing housing attached only to pump body; rotors controlled axially by ball bearings, and radially by precision timing gears and roller bearings; all parts positioned automatically by shoulders and locknuts; available with corrosion-resistant alloy parts, steam jacketed bodies, special stuffing boxes and bearings for high-temperature use, hopper type bodies for high viscosities

Application: For moving nonlubricating fluids and semifluids such as water, distillates, hot oils, cellulosics, etc., in petroleum marine, processing and power installations.

For more data circle MD 5, Page 185

Miniature D-C Relay 6

Struthers-Dunn Inc., 150 N. 13 St., Philadelphia 7, Pa.

Designation: Frame 220; Type A (high temp), Type B (normal temp)

Style: Multipole (2, 3, 4, and 6) double-throw; hermetically sealed; end studs or mounting feet

Size: Can 1⅛-in. diameter x 1½ in. long, 3 oz; 8-32 studs(2)

Service: Air Force Spec MIL-R-5757; operating time 0.005 seconds; contacts nominally rated 2 amps, 28v d-c noninductive with 12 amp inrush; Type A temp range −65 to +200 C, Type B −65 to +85 C; rated voltage 26.5v d-c; will operate on continuous voltage of 18 to 32v, withstands rapid fluctuations between 10 and 38v; withstand 50 *g* shock or 10 *g* vibration; power consumption at rated voltage 2 watts (max temp), 3 to 5 watts (room temp), 1 watt at min operating 18v; insulation resistance 100 megohms dry; breakdown 1250v 60-cycle a-c

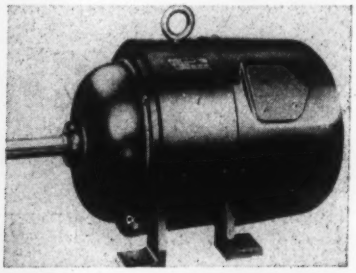
Design: Palladium contacts break-before-make type, normally closed contacts open before normally open close; rotating solenoid type magnetic structure and balanced moving parts eliminate contact bounce or false operation; hermetic seal insensitive to humidity and altitude changes

Application: Aircraft—Type A for guided missiles and pilotless craft, Type B for conventional craft; general—for electrical circuits where shock, vibration, temperature extremes, moisture, or corrosive atmospheres are encountered.

For more data circle MD 6, Page 185

Explosionproof Motor 7

Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.



Designation: Life-Line

Style: Explosionproof; nonventilated or fan-cooled; series, shunt or compound-wound

Size: ½ to 20 hp; frames 203-365

Service: 850 to 3500 rpm; temperature rise limit 55C; 230, 250, 500, and 550 v d-c

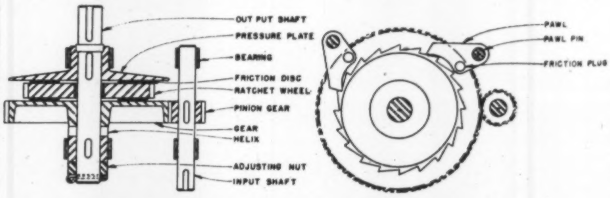
Design: In accord U. S. Bureau of Mines; all-steel construction, one-piece rolled-steel frames; prelubricated double-sealed ball bearings, field and armature windings impregnated in thermoset varnish for moisture resistance; power cable brought out through packing glands; rotating flame seals at each bearing, long rabbet fit between frame and brackets, screw type brass access cover

Application: For machine drives where motor must be able to withstand possible internal explosions or must not ignite an explosive mixture in the surrounding area.

For more data circle MD 7, Page 185

Mechanical Load Brake 8

Downs Crane & Hoist Co., Los Angeles 37, Calif.



Style: Two disk Weston type, automatic

Size: Five sizes from 16⅞ h x 28⅛ d x 21¼-in. wide (including 3¾-in. input and 4-in. output shaft extensions) to 28⅝ h x 37 d x 32½-in. wide (including 4-in. input and 6-in. output); respective weights 340 lb to 1420 lb

Service: Standard gear reduction 5:1; rotation in either direction

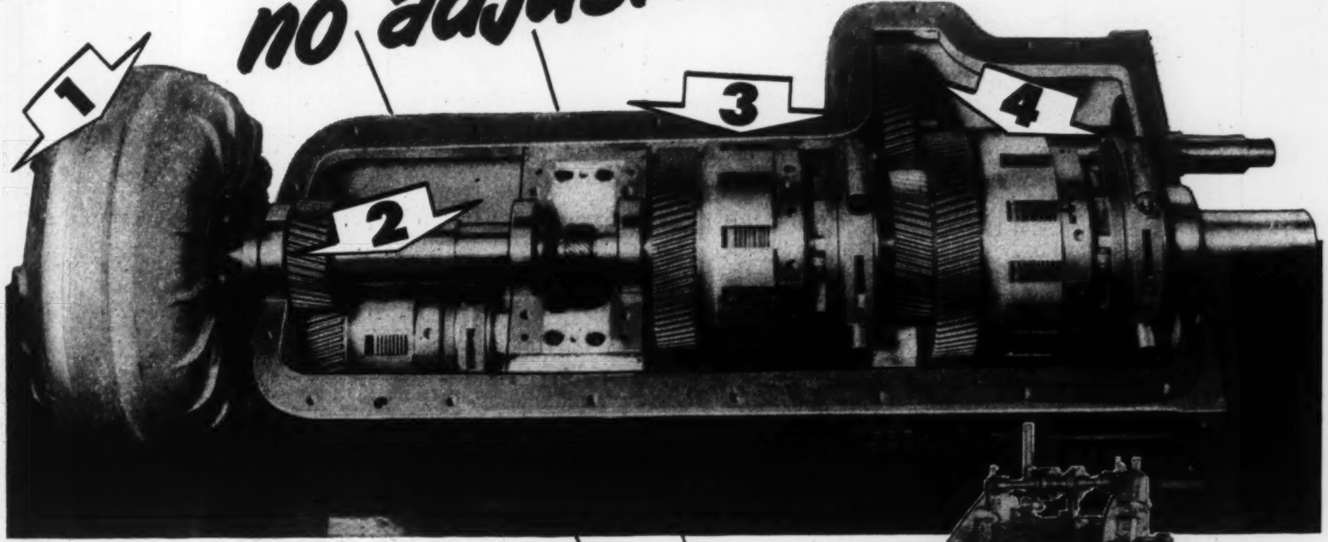
Model	Drive Motor (max hp) 1200 rpm	900 rpm	720 rpm	600 rpm	Input Torque Capacity (lb.-in.)
3523	10	7½	5	3	600
3525	20	15	10	7½	1200
3527	30	25	20	15	2000
3529		40	30	25	3000
3531		60	50	40	5000

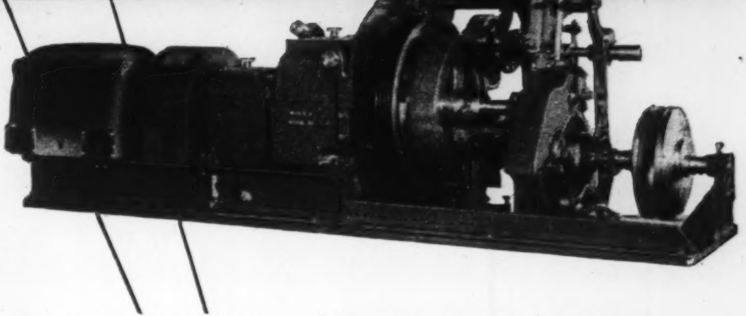
Design: Built into second (low-speed) shaft of single, double or triple reduction units; pawls contact ratchet wheel to prevent load running; motor exerts pressure on helix to open brake while lowering—if motor stops, load exerts axial thrust which clamps friction disks on ratchet to stop rotation; opening and closing of brake in direct proportion between load and motor speed; pawls lifted clear of wheel for raising loads; starting torque 300% normal running torque; brake housing oil tight, unit in oil bath

Application: For automatic positive control of the lowering speed of cranes, etc.

For more data circle MD 8, Page 185

No belts to slip... no adjustments to make





On Johnson and Bassett's 360-spindle mule, largest manufactured in the United States, streamlined power is achieved in the Hydroline Drive by replacing overhead belts and countershafts with a Twin Disc Hydraulic Coupling, figure 1, and three Twin Disc Model MTS Machine Tool Clutches, figures 2, 3 and 4.

Overhead belts and countershafts, with their multiplicity of hazard, operating and maintenance problems, are replaced with a compact, streamlined transmission unit in the Johnson and Bassett HYDROLINE DRIVE Mule.

And one result has been a 10 to 20 per cent *increase in production.*

The transmission includes a Twin Disc Hydraulic Coupling and three Twin Disc Machine Tool Clutches. The fluid coupling assures smooth, shock-free starting, permits the motor to come up to working torque fast to maintain uniform spindle speeds.

With no belts to slip, no adjustments to make for extended periods, the whole operation is cleaner, safer. And smooth power assures higher quality yarns, from the coarsest to the finest.

Why not investigate Twin Disc Hydraulic Couplings with their *smooth* power-flow performance. Investigate, too, Twin Disc Machine Tool Clutches with instant release and high torque capacity in the most compact space. It will pay you to obtain complete information. Write today for engineering bulletins.

Clutches & Hydraulic Drives

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

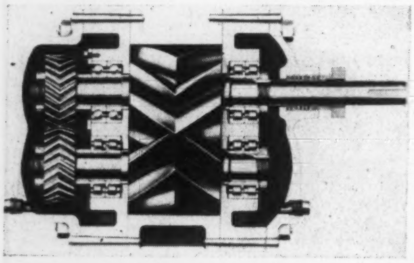
BRANCHES: CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEWARK • NEW ORLEANS • SEATTLE • TULSA

NEW PARTS AND MATERIALS

Fluid Pressure Pump

9

Warren Steam Pump Co. Inc., Warren, Mass.



Designation: Streamflow Rotex

Style: Rotary gear type, positive displacement; bearing-and-gear in head (lubricating fluids), external bearing-and-gear (nonlubricating fluids); bedplate, pedestal or bracket mounted

Size: Suction and discharge ports from 1 to 8 in.

Service: Liquids and viscous fluids; capacity to 1000 gpm, pressures to 250 psi; max fluid viscosity 100,000 SSU.

Design: Herringbone pumping rotors are prevented from contacting by thrust bearings and timing gears mounted on drive shaft; deep stuffing box accommodates 6 to 8 packing rings; jacketed bodies for operating temperature extremes; bodies close-grained cast iron, driving gears steel or Meehanite, shafts heat-treated alloy steel, glands bronze

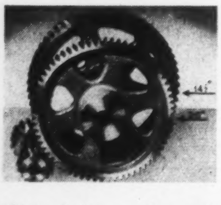
Application: For circulation of moderate viscosity fluids at medium pressures.

For more data circle MD 9, Page 185

Spur Gears

10

Boston Gear Works, 64 *Hayward St., Quincy* 71, *Mass.*



Style: Plain (steel); plain, web and spoke (cast iron)

Size and Service: Hole sizes listed increase at ⅛-in. increments through range indicated

Pitch	Pitch Diameter (in.)	Hole Diameter (in.)	HP and Load (1200 rpm, 25 teeth)	Face Width (in.)
5	2.4 to 4.0 (steel)	1⅛	16.5 452	2½
	4.8 to 36 (cast iron)	1⅛ to 1⅝		
6	2.0 to 3.5 (steel)	1	11.0 301	2
	4.0 to 24 (cast iron)	1⅛ to 1⅜		
8	1.5 to 3.5 (steel)	¾ to ⅞	6.13 169	1½
	4.0 to 24 (cast iron)	1 to 1¼		
10	1.2 to 2.8 (steel)	⅝ to ⅞	4.13 113	1¼
	3 to 20 (cast iron)	⅞ to 1⅛		
12	1 to 2.5 (steel)	½ to ¾	2.75 75	1
	3 to 20 (cast iron)	¾ to 1		

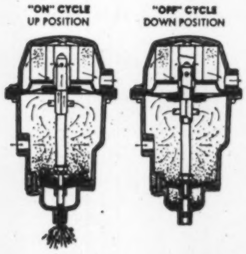
Design: Involute profile; 20-degree pressure angle, as compared to 14½, permits wider tooth base, stronger tooth, longer contact surface, minimized undercut, increased hp/lb, and reduced weight and size; will not operate with 14½-degree gears.

For more data circle MD 10, Page 185

Automatic Air Filter

11

Wilkerson Valve Inc., Denver, Colo.



Style: Diaphragm type; combination separator and automatic drain

Size and Service: Compressed air filtering for intermittent flow systems; pressure drops 25 psi at 38 cfm 100 psi (Model 1002), 28 psi at 100 cfm 100 psi (Model 1051), and 30 psi at 135 cfm 100 psi (Model 1052)

Model	Pipe Size (in.)	Air Capacity (cfm, 100 psi)	Air Pressure (psi)	Dia. × Height (in.)
1002	¼	1 to 28	15 to 200	4⅝ × 7⅝
1051	⅜	1 to 62	15 to 250	6 3/16 × 8⅝
1052	½	1 to 94	15 to 250	7½ × 11⅝

Design: Installed downstream from pressure regulator or manifold controls; when air is off, diaphragm is forced down by backpressure and O-ring on center shaft seals bottom sump—return of air pressure raises diaphragm and shaft, compressed air forces contaminants from sump

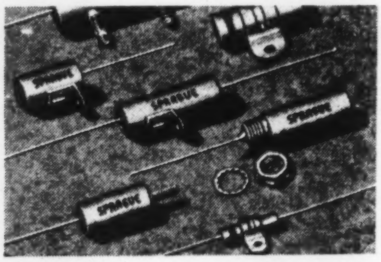
Application: For stationary or moving equipment employing pneumatic power systems, portable air tools, etc.

For more data circle MD 11, Page 185

Subminiature Capacitors

12

Sprague Electric Co., North Adams, Mass.



Designation: 78P, 81P, 86P, 178P, 181P and 186P (one end grounded); 88P, 91P, 96P, 188P, 191P and 196P (both ends insulated)

Style: Metal-encased paper capacitors, hermetically sealed; tiny threaded-neck, side stud, end stud, vertical bracket mount, or horizontal bracket mount

Size: Capacity, 0.001 to 1.0 mfd; can diameters 0.195-in. and under, 0.235 to 0.312-in., and 0.400-in. and over; leads AWG 24, 22 and 20 respectively except thin thread neck 0.900-in. which takes AWG 22; lead lengths 1⅝-in.; studs No. 6-32, ⅜-in. long

Service: −40 C to +85 C temp, 100 to 400 v (78P, 88P, 178P, 188P); −55 C to +85 C, 100 to 1000 v (81P, 91P, 181P, 191P); −55 C to +125 C, 100 to 1000 v (86P, 96P, 186P, 196P)

Design: Inserted tab, wax impregnated (78P, 88P); inserted tab vitamin Q impregnated (81P, 91P, 86P, 96P); extended foil, wax impregnated (178P, 188P); extended foil, vitamin Q impregnated (181P, 191P, 186P, 196P). Capacitance tolerance ±5, ±10, and ±20%

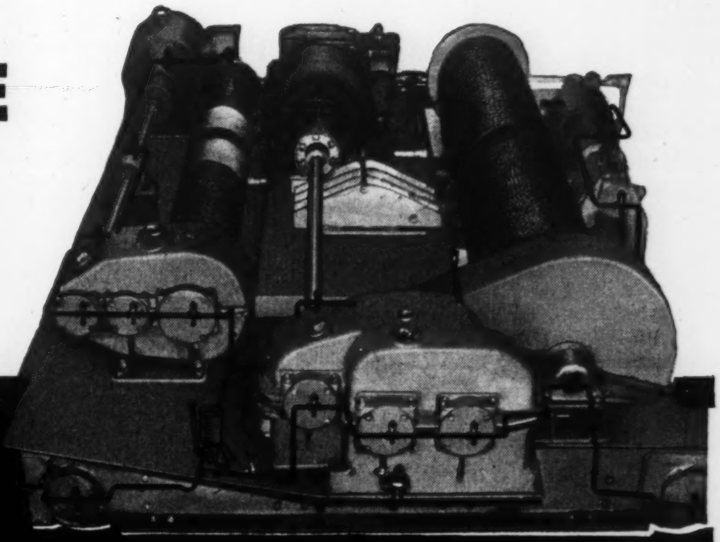
Application: Specially suited for circuits where vibration and shock problems are encountered.

For more data circle MD 12, Page 185

3 ways

TO DESIGN MORE PRODUCTION

into your machines!



ALEMITE

REG. U. S. PAT. OFF.

Accumeter

automatic lubrication

reduces maintenance, increases machine output

When you design Alemite Accumeter Automatic Lubrication into your machines, you end the need to shut down for lubrication . . . thus adding many hours of profitable production time! An Accumeter System is made up of a lubricant pump, a distribution system of tubing, and *force-feed* valves for individual bearings. From one central point, it automatically lubricates all the bearings on a machine . . . while the machine continues to produce. Eliminates the risks of lubrication errors or neglect by your customers! Soon pays for itself in increased production . . . man hours, lubricants and repair costs saved!

Alemite Accumeter Systems meter oil or grease to bearings with a degree of accuracy never before achieved. In fact, even after 73,312 lubrication cycles, equal to 122 years of twice-a-day service . . . tests show *no variation* in the amount of lubricant discharged! What's more, lubrication is either fully hydraulic or continuous between cycles, thanks to Alemite's exclusive "accumulating" feature that *prolongs* the discharge of lubricant to bearings!

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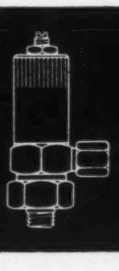
There are three different Alemite Accumeter Automatic Lubrication Systems, to cover your full range of requirements. Versatile in application, they are adaptable to practically any machine. Write now for free bulletin giving full data. Alemite, Dept. R-51, 1850 Diversey Pkwy., Chicago 14, Illinois.

TYPE 0

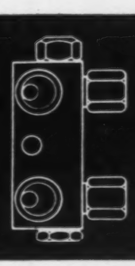
MIDGET OIL VALVES
Fixed output metering valves for single line system serving up to 200 small bearings. Especially suited to precision machines, and wherever space is limited.

TYPE I



ONE-BEARING VALVES
Oil or grease metering valves with *fixed or adjustable output*, for single line system. Valves for any bearing capacity. Single system serves up to 400 bearings.

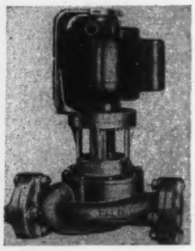
TYPE II



TWO-BEARING VALVES
Adjustable output metering valves for oil or grease. Each serves 2 bearings. System handles up to 600 bearings. Manual or automatic operation.

Circulating Pump 13

Taco Heaters Inc., 137 *South St., Providence* 3, *R. I.*



Style: Enclosed impeller with double inlet; direct connected to motor

Size and Service: Inlet flanges 3-in., four-bolt fastening

Model	Motor (hp)	Capacity (gpm) 5-ft head
HC 34	1/3	120
HC 36	½	144
HC 38	¾	167

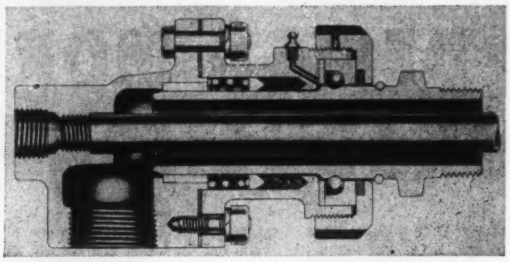
Design: Synthetic rubber drive coupling to isolate motor from impeller; hardened and superfinished stainless-steel impeller shaft; self-lubricating porous bronze shaft bearing; carbon and stainless steel spring-loaded mechanical seals; installed in six positions

Application: For forced circulation of water through systems for heating, dishwashing, etc.

For more data circle MD 13, Page 185

Revolving Joint 15

Barco Mfg. Co., Chicago, Ill.



Designation: Type IBR

Style: Single-flow or two-way flow with syphon tube; straight or angle connections

Size: Standard ½ to 2-in. pipe; others special

Service: Hydraulic fluids 200 psi 750 rpm max, steam 150 psi 500 rpm max, and vacuum; temperatures to 450F, depending on packing specified

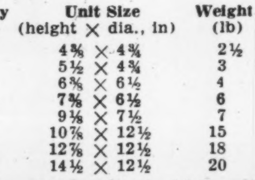
Design: High-temperature or cold service packing—self-adjusting chevron packing spring-loaded; rotating heat-treated steel nipple screws to drum hub; nonrotating element ball bearing mounted on tube, bearings take radial and axial thrust; sleeve pilot bearing at end of rotating tube insures against twisting or cocking; joints can be serviced without removal

Application: For making piping connections to drum type dryers, rolls, calenders, and other rotating equipment; syphon model for removal of condensate, gases, etc. at point where fluid enters.

For more data circle MD 15, Page 185

Hydraulic Filter 14

Dollinger Corp., 11 *Centre Park, Rochester* 3, *N. Y.*



Designation: Staynew

Style: Radial fin insert

Size and Service: Hydraulic and coolant fluids; capacities listed are based on clean 100 SSU oil at 100 F with 100 mesh media

Model	Pipe Size (in.)	Filter Area (sq ft)	Capacity (gpm)	Unit Size (height × dia., in)	Weight (lb)
HE-1	1	1.0	5	4⅜ × 4¾	2½
HE-2	1	1.4	7	5½ × 4¾	3
HE-3	2	2.7	14	6⅜ × 6½	4
HE-5	2	3.4	17	7⅜ × 6½	6
HE-7	2½	4.1	21	9⅛ × 7½	7
HE-10	3	9.7	49	10⅞ × 12½	15
HE-15	3	11.6	58	12⅞ × 12½	18
HE-20	3	14.3	72	14½ × 12½	20

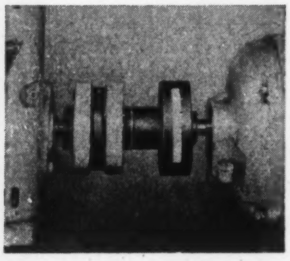
Design: Radial fin insert fine mesh sheet (A) with coarse screen backing (B) in accordion folds; insert stainless steel, monel, bronze, inconel, brass, galvanized steel, aluminum, or fabric; upper end plate (F), perforated supporting tube (C) and threaded outlet sleeve (E) welded as one unit; bottom end plate (G) fastens to screw on supporting tube and is element removed for replacing filter; large filter area for reduced backpressure and extended period of operation; thick felt gaskets (D)

Application: For hydraulic power or coolant circuits where dirty fluids are collected and recirculated—lathes, mills, plastic molding machines, conveyers, hydraulic presses, etc.

For more data circle MD 14, Page 185

Mercury Clutch Coupling 16

Mercury Clutch Div., Automatic Steel Products Inc., Canton 6, *O.*



Designation: Series E

Style: Centrifugal

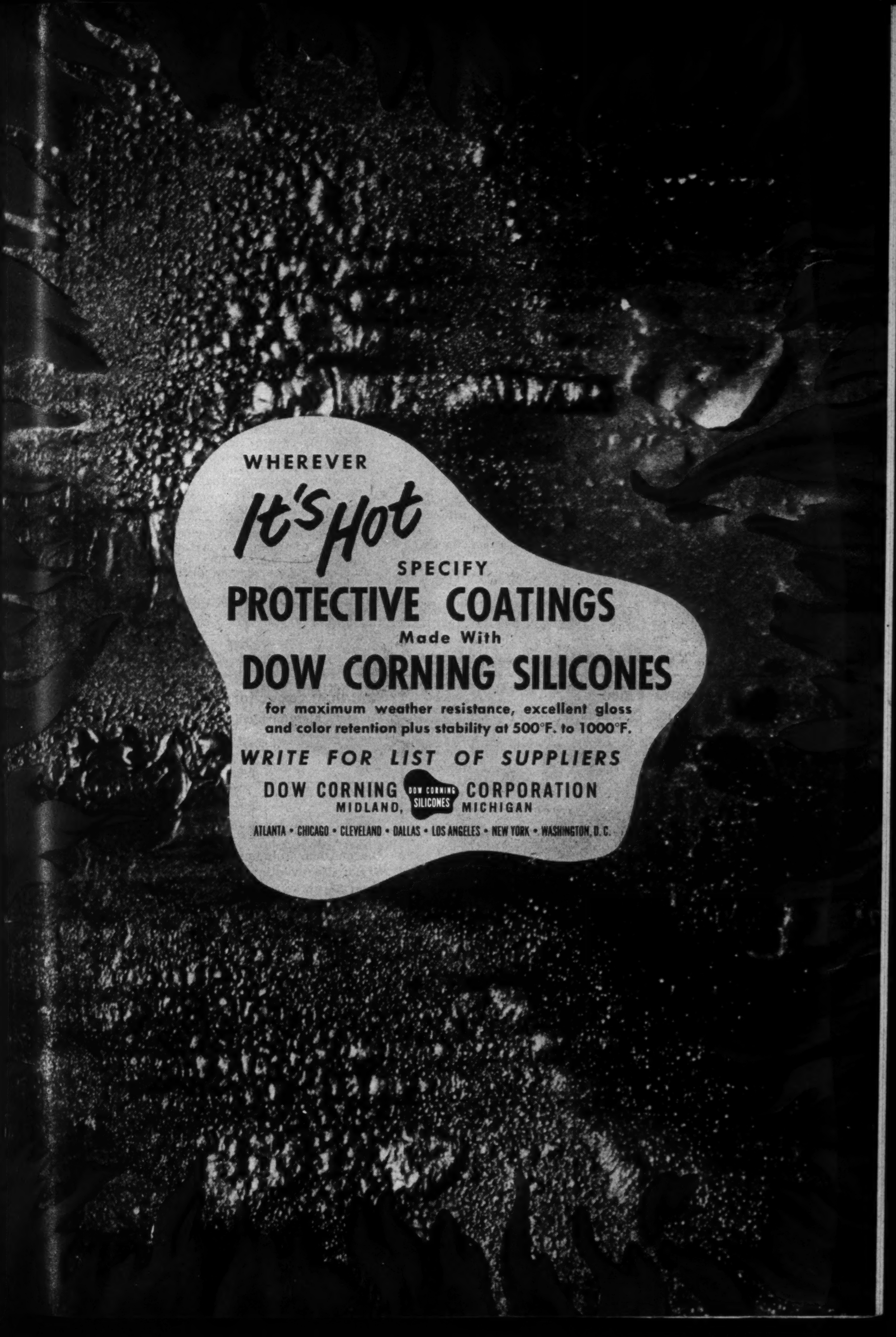
Size and Service:

Horsepower (hp)	Synchronous Speed (rpm)	Shaft Diameter (in.)
¼, ⅓, ½	1200	¾
¾, 1	1200, 1500	¾
1½, 2, 3, 5, 7½, 10	1200	1, 1, 1⅛, 1½, 1⅝, 1⅞
1½, 2, 3, 5, 7½, 10, 15	1500, 1800	¾, 1, 1, 1⅛, 1¼, 1⅝, 1⅞

Design: Mercury in rubber envelope actuates clutch shoes at predetermined centrifugal force; one hub bored to receive motor drive shaft, other has keyed shaft extension for connection to driven load, flexible coupling, etc.

Application: For providing controlled engagement at predetermined speed between electric motor drives and driven units.

For more data circle MD 16, Page 185



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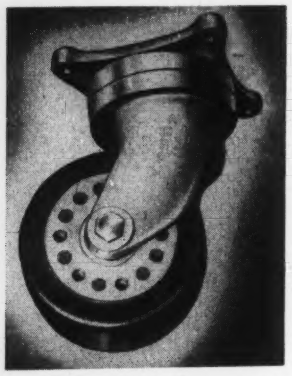
NEW PARTS AND MATERIALS

Industrial Caster 17

Aerol Co. Inc., 2820 Ontario St., Burbank, Calif.



Style: Swivel, solid treaded wheel

Size: Accommodates 8½-in. wheel; 1¼-in. kingpin

Service: Load rating, 2000 lb

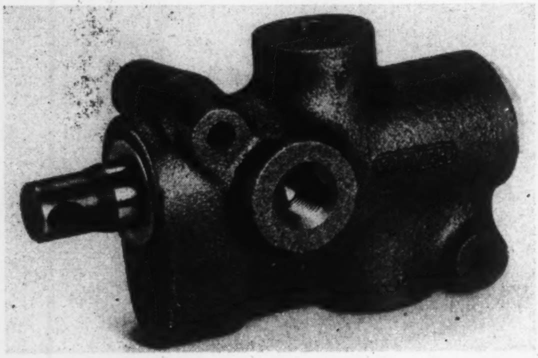
Design: Chrome molybdenum steel kingpin; cast prime aluminum alloy frame; patented Aerol seal isolates axle and bearings from foreign matter (including steam) and seals in special lubricant (Lubriko Master M-21); Timken or Bower roller bearings; wheel withstands thrust loads of 40-60,000 lb

Application: For heavy-duty mobile materials handling equipment.

For more data circle MD 17, Page 185

Hydraulic Control Valve 18

Parker Appliance Co., Cleveland, O.



Style: Open center, single spool, 3-way

Size: Cylinder and pressure ports ¼, ⅜ or ½-in. internal pipe thread, return port ¾-in.

Service: Hydraulic fluids to 2000 psi max; 14 gpm. max; pressure drop through open center 10.25 psi at 14 gpm.

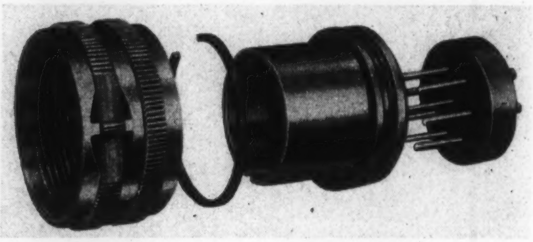
Design: Pressureproof castings, hardened steel moving parts; standard lip type seals; externally adjustable. built-in, balanced relief valve; raise, lower and locked holding position standard, float position special

Application: For hydraulic circuit pressure control on heavy-duty farm implements, construction and materials handling machinery.

For more data circle MD 18, Page 185

Hermetically Sealed Connectors 19

Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Calif.



Designation: Type RSO6

Style: Plug-in barrel shell with or without coupling nut, flange or mounting holes

Sizes: Shell dimensions similar to mating portion of standard AN3106

Service: 120 v 10 amp (up to 12 No. 16 and 2 No. 12 contacts), 28 v 10 amp (up to 14 No. 16 contacts) and 28 v 3 amp relays (to 14 No. 16 contacts); contacts larger than No. 8 cannot be furnished because of required soldering heat

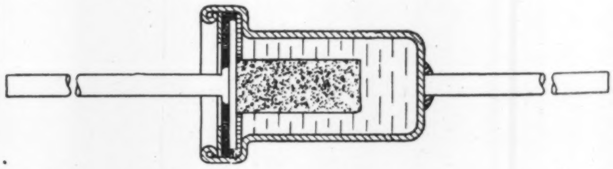
Design: Internal plug conforms to AND 10459 spec classification D; polychloroprene rubber insulators with resistance in excess 25,000 megohms at 25 C; coupling nuts diecast, rib design or dural with straight knurling and natural finish; contacts AN type, brass, nonrotating in insert and nonremovable; short solder pots decrease overall dimensions and facilitate assembly

Application: For aircraft relays and other sealed components.

For more data circle MD 19, Page 185

Tantalum Capacitors 20

Fansteel Metallurgical Corp., North Chicago, Ill.



Designation: Subminiature series

Style: Electrolytic; polarized

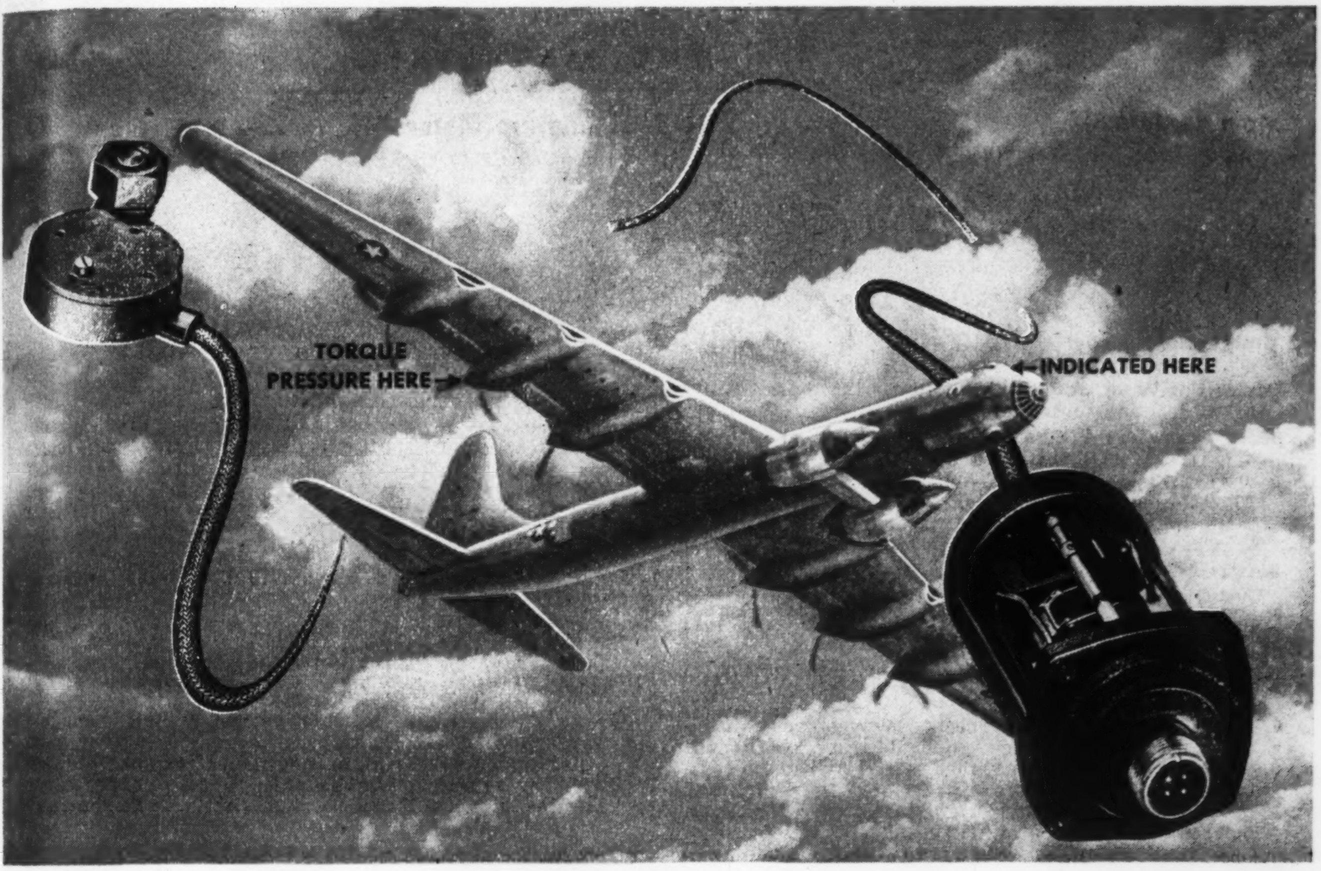
Size: 3$\frac{31}{64}$-in. overall with 1½-in. leads, $\frac{5}{16}$-in. diameter; occupy 1/10-cu. in. space excluding connection leads

Service: Capacity 30, 25, 20, 15, 10, 8, 5, 4, and 3.5 mfd at 6, 8, 10, 15, 25, 30, 50, 60, and 75 v d-c respectively; operating temperatures to 185 F.

Design: Porous tantalum anode assembly; fine silver cathode; installed in any position; leakage only a few microamps; no shelf aging.

Application: For industrial electronic circuits where stable characteristics are required and sizeable charge storage capacity is desired in limited space.

For more data circle MD 20, Page 185



A NEW APPROACH IN AIRCRAFT TORQUE PRESSURE INSTRUMENTATION

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- Nispan "C" pressure elements eliminating bimetallic compensation.
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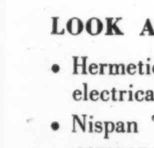
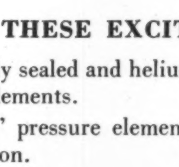
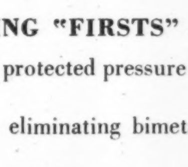
United States Gauge, Division of
American Machine and Metals, Inc.,
Sellersville, Pa.



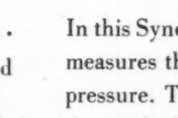
USG
Oil Pressure Gauge



USG
Fuel Pressure Gauge



USG
Manifold Pressure Gauge



USG
Hydraulic Pressure Gauge

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OTHER DIVISIONS OF AMERICAN MACHINE AND METALS, INC., AT SELLERSVILLE, PA.: GOTHAM INSTRUMENTS AND AUTOBAR SYSTEMS

NEW PARTS AND MATERIALS

Steel Casters

21

Bond Foundry and Machine Co., Manheim, Pa.

Designation: Model 40-A-MH (swivel), Model 41-A-MH (rigid).

Style: Semisteel, soft or hard rubber tread (oil-resistant if desired), and Celeron wheels

Size: Diameters 5, 6, 8, 10-in. x 2½-in. width; overall height 7⅝, 8⅛, 10½, and 12½ in. respectively; weight 18½, 20¼, 26½, and 30½ lb (swivel) 14½, 16, 22½, and 26½ lb (rigid); plate 7⅛ x 5¼ in.; mounting ½-in. bolts in 4 holes on 5¼ x 3⅜-in. centers

Service:

Wheel Diameter (in.)	Load Capacity (lb)		
	Semisteel or Celeron	Vulcanized Rubber Soft	Hard
5	1800	390	780
6	2300	450	900
8	2300	560	1120
10	2300	660	1320

Design: Ball bearing surfaces of swivel caster hardened; Hyatt type wheel roller bearings with split outer raceways held parallel to axle with steel retainer; roller bearings revolve on hardened and ground steel sleeve held rigid in fork by steel axle bolt; pressure lubricating fittings.

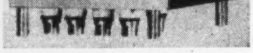
Application: For mobile heavy-duty material handling equipment.

For more data circle MD 21, Page 185

Electronic Delay Timer

22

G. C. Wilson & Co., Chatham, N. J.



Style: Hermetically sealed; SPDT

Size: Can 2 5/16 x 2 1/16 x 3⅛-in. high

Service: Time interval 0.1 to 10.0 seconds (factory preset), longer intervals special; 105-125 v, 360-1200 cycles—60 cycle and d-c also available; power consumption ½ watt in standby, 4 watts operated

Design: Balanced armature construction to resist shock and vibration; instantaneously recycling or with delay proportional to time between operations; requires no warmup; unaffected by line frequencies and voltage or temperature variations

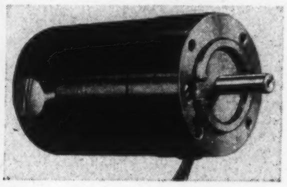
Application: For electric control circuits where fixed time delay is desired.

For more data circle MD 22, Page 185

Miniature Motor

23

John Oster Mfg. Co., Racine, Wis.



Style: Totally enclosed, rabbet mount

Size and Service: All motors continuous duty; models CH-306 and CU-306 3 31/32-in. long with 29/32-in. shaft extension, models CU-318 4 3/32-in. with 29/32-in. shaft extension; housing diameters all models 1 15/16-in.; lead lengths 6 in.; standard 1¼-in. diameter Air Corps rabbet; weight 1 lb; max temp rise 55C; ratings listed below based on 25C rise

Model	HP	Full-Load Speed (rpm)	Full-Load Current (amp)	Voltage	Winding
CH-306	1/300-1/75	1500-7500	0.48-0.96	24v d-c	shunt
CU-306	1/150-1/75	3800-7500	0.64-0.95	24v d-c	series
CU-306	1/200-1/100	3800-7500	0.58-0.83	24v d-c	split series
CU-318	1/150-1/75	3800-7500	0.15-0.22	115v d-c	series
CU-318	1/190-1/90	3800-7500	0.15-0.22	115v d-c/a-c	series

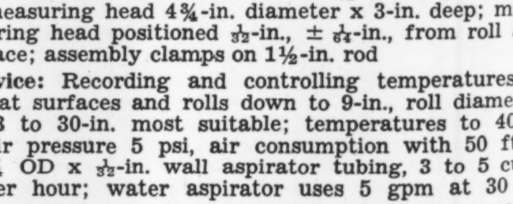
Design: Aluminum housing; shielded ball bearings grease lubricated; insulated copper windings varnish impregnated; highgrade metal-graphite brushes for low voltage, electrographite for high; brush tubes protected with threaded steel caps which screw to housing—caps also reduce radio interference.

For more data circle MD 23, Page 185

Temperature Control

24

Leeds & Northrup Co., Philadelphia 44, Pa.



Style: Noncontact; water or air aspirator with thermocouple; Micromax or Speedomax recording controller

Size: Overall dimensions 13 h x 6½ w x 7½-in. deep; measuring head 4¾-in. diameter x 3-in. deep; measuring head positioned 1/32-in., ± 1/64-in., from roll surface; assembly clamps on 1½-in. rod

Service: Recording and controlling temperatures of flat surfaces and rolls down to 9-in., roll diameters 23 to 30-in. most suitable; temperatures to 400F; air pressure 5 psi, air consumption with 50 ft of ¼ OD x 1/32-in. wall aspirator tubing, 3 to 5 cu ft per hour; water aspirator uses 5 gpm at 30 psi

Design: Minimum temp difference of −4F (at 400F) between roll and head; copper-constantan couple, suction tube and insulating block shrouded by stainless steel shell; measuring head adjustable concentric with roll; protective bumper and lever triggered by foreign material on roll to retract measuring head, thereby avoiding roll or assembly damage

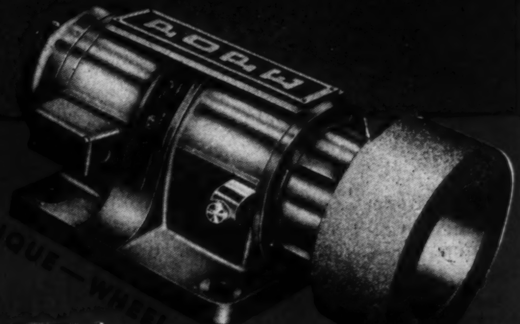
Application: For controlling operating temperature of metal-roll calenders, dryers, etc., where contact between control and heated surface is not desired.

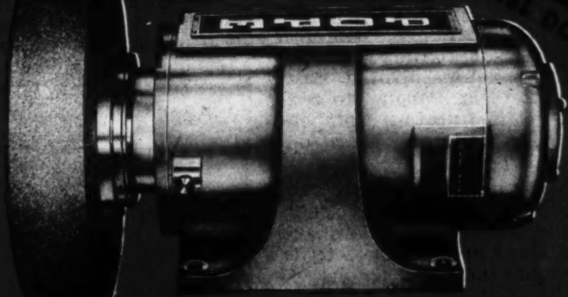
For more data circle MD 24, Page 185

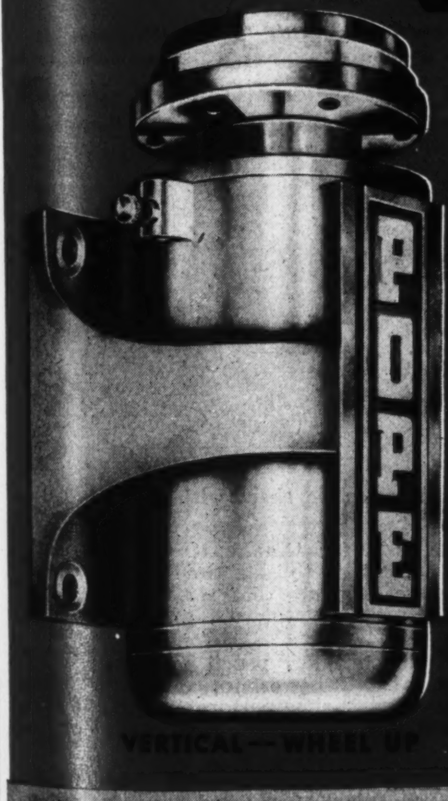
Specify POPE

2500 SERIES—HEAVY DUTY MOTORIZED SPINDLES

OBLIQUE—WHEEL UP


OBLIQUE—WHEEL DOWN

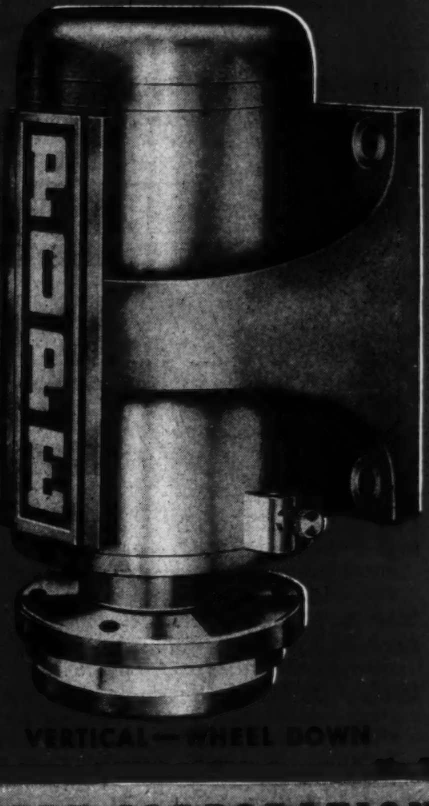

HORIZONTAL


VERTICAL—WHEEL UP

OPERATING POSITIONS

These P-2500 Series Spindles can be operated in any position . . . vertical, horizontal or at any oblique angle.

It is necessary, however, that the operating position be specified in your order.


VERTICAL—WHEEL DOWN

POPE

TRADE MARK REG. U.S. PAT. OFF.

POPE MACHINERY CORPORATION

ESTABLISHED 1920

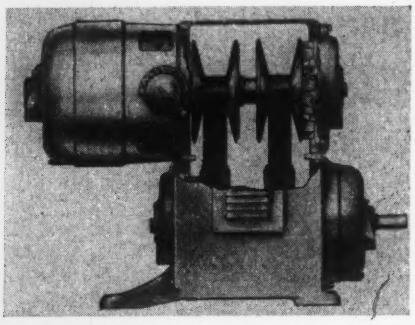
261 RIVER STREET • HAVERHILL, MASSACHUSETTS

BUILDERS OF PRECISION SPINDLES

NEW PARTS AND MATERIALS

Adjustable-Speed Drive 25

U. S. Electrical Motors Inc., 200 E. Slauson Ave., Los Angeles 54, Calif.



Designation: Varidrive

Style: Totally enclosed motor with dual-belt transmission; upright case, foot mounted

Size: 25 to 50 hp

Service: Heavy-duty; speed range from 2 to 10,000 rpm, ratios 10:1

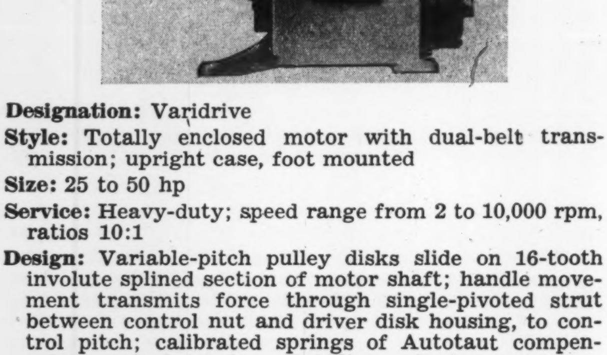
Design: Variable-pitch pulley disks slide on 16-tooth involute splined section of motor shaft; handle movement transmits force through single-pivoted strut between control nut and driver disk housing, to control pitch; calibrated springs of Autotaut compensator control tension of belts; reducing gears optional

Application: For driving machines or equipment subjected to extraheavy-duty loads—high-speed gearing for aircraft test stands, rubber extruders and blending mills, ore crushers, large machine shop tools, and machines used in the lumber industry.

For more data circle MD 25, Page 185

Cylinder Packing Assembly 26

Hydraulic Accessories Co., 439 E. Fort St., Detroit 26, Mich.



Designation: Monopak

Style: Self-contained rod packing cartridge; plain, shouldered with rod wiper and shouldered with wiper and integral snap ring

Size: Rod diameters from ⅝ to 3½-in.

Service: Air or hydraulic fluids; light-duty to 750 psi max, heavy duty to 2000 psi max.

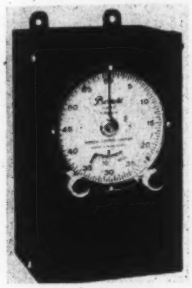
Design: Cartridge slides into bore, retained with snap ring; sealed to cylinder housing by O-ring in cartridge; bronze cartridge housing acts as rod sleeve bearing; Monopak metallic packings; Seal-Guard rod wiper

Application: For sealing pneumatic and hydraulic cylinder rods where elimination of conventional stuffing boxes is desired for designing and servicing simplification.

For more data circle MD 26, Page 185

Synchronous Motor Timer 27

General Control Co., Boston 34, Mass.



Designation: Type SY Promatic

Style: Totally enclosed, bracket mount; automatic reset; solenoid operated

Size: 4½ wide x 4⅛ deep x 8 in. high, including terminal stripes; dial diameter 3⅜ in.

Service: All time periods between ½-second to 24 hours; 115 or 230v a-c.

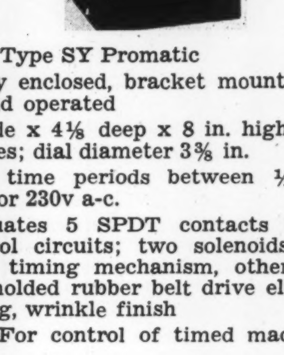
Design: Actuates 5 SPDT contacts independent of timer-control circuits; two solenoids—one operates clutch and timing mechanism, other actuates load contacts; molded rubber belt drive eliminates gears; cast housing, wrinkle finish

Application: For control of timed machine functions.

For more data circle MD 27, Page 185

Timing Disks 28

Allegheny Plastics Inc., 425 Chestnut Rd., Sewickley, Pa.



Style: Thin circular plastic sheet with printed dial

Size: 8-in. diameter

Service: Control disk for time control instruments, can be edge perforated to suit time cycle desired; graduation ranges to suit (56, 112, 168, 180, 224, etc., minutes); resists water, oil, grease, gasoline, alcohol, etc.

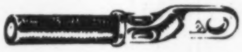
Design: "Satin" finish takes pencil markings which can be washed off; will not crimp; concentric timing track, close to edge, can be perforated without raising burr which would interfere with controller operation

Application: For time cycle controllers employed in the processing of rubber, chemicals, plastics, paints, etc.

For more data circle MD 28, Page 185

Solderless Wire Connector 29

Buchanan Electrical Products Corp., Hillside, N. J.



Designation: pres-SURE-termend

Style: Ring, spade and locking tongue

Size: Nos. 6, 8 and 10 all styles and ¼-in. (ring tongue only)

Service: Single wire solderless splice; wires accommodated—(No. 6) 16-8-6, (No. 8) 16-8-8, (No. 10) 16-8-10, and (¼-in.) 16-8-¼

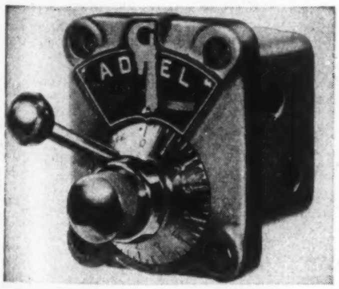
Design: One-piece copper construction; applied to wire with 4-way pressure crimp by C-24 pres-SURE-tool

Application: For termination of machine wiring where low cost and production speed are desirable.

For more data circle MD 29, Page 185

Hydraulic Valve 30

Adel Div., General Metals Corp., 10777 Van Owen St., Burbank, Calif.



Style: Flow-control; manual

Size: ⅜ and ¾-in. pipe ports

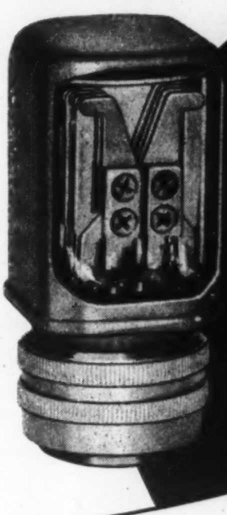
Service: Hydraulic fluids to 1500 inlet psi max; 1, 2, 4, and 6 gpm (⅜-in.); 10, 15, 20, and 25 gpm (¾-in.)

Design: Pressure compensated for constant flow; adjustable from complete shutoff to max flow; max recommended outlet pressure equals inlet pressure minus 100 psi; 270-degree control lever rotation; no drain line required.

(This valve was announced in the April issue with Adel listed incorrectly as a General Motors instead of a General Metals division.)

For more data circle MD 30, Page 185

AN approved (3303-1)



R-B-M

ELECTRONIC AND COMMUNICATION RELAYS

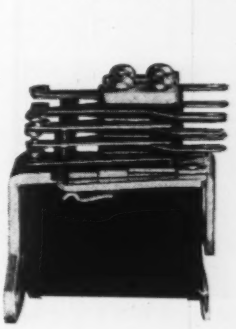
Now Hermetically Sealed

HUNDREDS of thousands of R-B-M telephone type relays saw Government service in World War II. Now most of these relays are available in hermetically sealed enclosures designed to meet AN specifications.

R-B-M hermetically sealed telephone type relays are available in contact forms up to and including 4-pole, double throw, 3 ampere, 28 Volts D. C. construction. Also 10 ampere rating up to and including 2-pole double throw at 28 Volts D.C. All relays available with approved AN plug connector, or with solder connections.

Engineers! What is YOUR hermetically sealed relay requirement? R-B-M is developing new and smaller relays to meet Armed Services requirements. Perhaps one of these will solve your problems. Write giving complete relay specifications, application, quantity and AN specifications applying. Address Dept. B-5.

AN approved (3304-1)



R-B-M Production and Engineering facilities in two plants, located in different states, (over a quarter million square feet), can assist you in the development and production of special electro-magnetic devices for Armed Services application.

RBM

R-B-M DIVISION
ESSEX WIRE CORP.
Logansport, Indiana

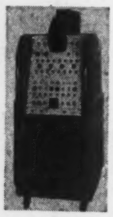
MANUAL AND MAGNETIC ELECTRIC CONTROLS
—FOR AUTOMOTIVE, INDUSTRIAL, COMMUNICATION AND ELECTRONIC USE

ENGINEERING DEPARTMENT
EQUIPMENT

For additional information on this new equipment, see Page 185

Strain Analyzer 31

Electronic Tube Corp., 1200 *E. Mermaid Lane, Philadelphia* 18, *Pa.*



Designation: H-42A Strainalyzer

Style: Self-contained, mobile; SR-4 strain gage measuring element, cathode tube scope; Fairchild 246A recording camera

Size: 30 wide x 33½ deep x 60-in. high, 381 lb, including camera; 5-in. scope

Service: Observation and recording of four traces simultaneously; magnifies strain 20,000 times; frequency range 0 to 50,000 cps 0.5 db; linear sweep durations to 10 seconds for low frequency study—1/10 cps to 10 kc; type A and C strain gages with 60 to 500-ohm resistances; unit power consumption 400 watts at 115v 60 cycle; camera power consumption 135 watts at 115v 60-cycle

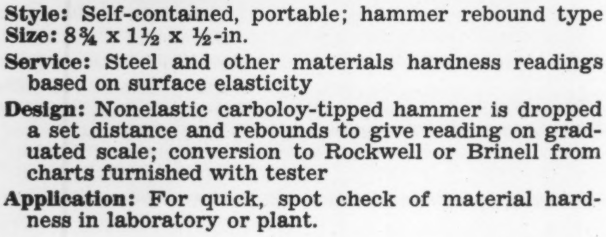
Design: Bridge d-c excited from self-contained batteries which may be replaced by external heavy-duty type for long-term tests; cathode tube special four-gun design; high-gain d-c amplifiers, balance controls, and voltage and calibration controls for each of four gage bridge channels; calibration circuits accurate within 1%; individual units may be removed for rack mounting

Application: For stress studies of rockets, jet engines, aircraft, automotive equipment, drop hammers, presses, internal combustion engines, and all rotating and reciprocating mechanisms.

For more data circle MD 31, Page 185

Hardness Tester 32

A. H. Co., Brighton, Mich.



Style: Self-contained, portable; hammer rebound type

Size: 8¾ x 1½ x ½-in.

Service: Steel and other materials hardness readings based on surface elasticity

Design: Nonelastic carboloy-tipped hammer is dropped a set distance and rebounds to give reading on graduated scale; conversion to Rockwell or Brinell from charts furnished with tester

Application: For quick, spot check of material hardness in laboratory or plant.

For more data circle MD 32, Page 185

Photocopy Camera 33

Haloid Co., Rochester 3, *N. Y.*

Style: Self-contained electrostatic reproduction

Size: 20 high x 16 wide x 31½ in. deep; 44 lb

Service: Multilith masters from material on opaque paper up to 8½ x 13 in.; photo element of Xerographic process (dry, direct positive, electrostatic reproduction) which involves three units: camera, copier and fuser; total process time 3 minutes

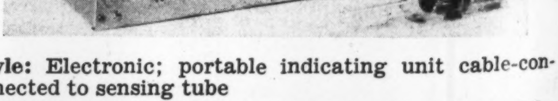
Design: Lens—extreme wide angle, 4¼ in. focal length fixed at f12.5; filter—yellow (app. K-2), filter factor 3; lights—4 No. 1 photoflood, 1000 watts total; timer—automatic reset, 0-60 seconds

Application: For engineering departments where multilith reproductions of charts, documents, standards, drawings and text are desired without the necessity of darkroom, plumbing, water, etc.

For more data circle MD 33, Page 185

Leak Detector 34

Distillation Products Industries, Div. Eastman Kodak Co., Rochester, N. Y.



Style: Electronic; portable indicating unit cable-connected to sensing tube

Size: Cabinet 10¼ wide x 7½ high x 8-in. deep; tube 5-in. long 1$\frac{5}{16}$-in. diameter; tubulation 3-in. long, $\frac{7}{16}$-in. OD.

Service: Vacuum systems to one micron Hg; d-c

Design: Current heats platinum anode of tube; tube fitted to system by stuffing box fitting; halogen containing gas such as Freon directed at leak spots reacts with anode to increase ion emission; dials for reading ion current and leak rate and sensitivity adjustment

Application: For detecting vacuum system leaks which are not evidenced by obvious signs.

For more data circle MD 34, Page 185

HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

80. Oilers

Eynon-Dakin Co.—12-page illustrated catalog B-3 shows complete line of Edco oilers, oil caps, vents and special tube forms. Various types are pictured, and specifications of each are listed.

81. Plastics Surfacing

General Electric Co., Chemical Dept.—16-page illustrated bulletin CDL-18 is entitled "G-E Textolite Plastics Surfacing." Shown in full color is new line of patterns which feature distinctive styling. Technical section covers abuse resisting properties of this material which affords excellent service as counter, table and other top surfaces.

82. Cold-Headed Fasteners

John Hassall, Inc.—36-page illustrated catalog No. 60 explains savings in operations and material costs through use of cold-headed fasteners. Vast variety of nails, rivets, screws and other specialties available through this fabrication method are shown. Technical data and specifications are given on all types of fastenings produced in both standard and special designs.

83. Industrial Brushes

Pittsburgh Plate Glass Co.—32-page illustrated File F-51524 "Case History Booklet" presents 12 examples of how industrial wire brushes for cutting, polishing, smoothing, cleaning or removing materials helped secure high quality work at low cost. Typical applications include cleaning weldments, finishing stainless steel sheets, removing sand from hot cast iron, reconditioning automotive connecting rods and removing burrs from steel.

84. Bronze Welding Electrodes

Ampco Metal, Inc.—24-page illustrated bulletin W-17 entitled "Welding With Ampco Bronze Electrodes" contains recommended welding techniques, procedures and machining suggestions that apply to various types of bronze welding electrodes available from this firm.

85. Terminals & Connectors

Thomas & Betts Co.—40-page illustrated bulletin No. 61 lists various types and sizes of Sta-Kon pressure terminals and connectors for providing secure mechanical grip on wire as well as suitable electrical connection. Terminals can be installed with high production bench tool or convenient hand tool.

86. Laminated Plastics

Taylor Fibre Co.—62-page illustrated 1951 catalog of laminated plastics gives engineering and application data on vulcanized and phenol fibers and on special laminates. Design factors and machining information are covered. Composition, mechanical and electrical properties, available forms, typical uses and other data are given on various grades of laminated plastics.

87. Compression Molding

Libbey-Owens-Ford Glass Co., Plaskon Div. —6-page bulletin A-3 lists advantages of compression molding Plaskon Alkyd and discusses characteristics of greatest interest to molders. Among these are increased molding machine productivity, improved efficiency in molding room operation and reduced maintenance costs on presses and tools.

88. Custom Steel Parts

Henry Disston & Sons, Inc.—16-page illustrated booklet "Disston Custom Steel Parts" explains facilities for producing flat steel parts to exact specifications. Products produced by company include circular, rectangular and odd shapes as well as intricate designs. Most replaceable flat steel parts requiring hardening, tempering and machining can be turned out.

89. Condenser Tubes

Revere Copper & Brass Inc.—28-page illustrated brochure "Life Extension for Condenser Tubes" reports on long research done on causes of corrosion and means of combating them as well as on choice of condenser tube materials. Use of radioactive elements or isotopes in determining correct proportion of third element to be added to copper-zinc alloy condenser tubes to offset dezincification is discussed also.

90. Copying Machines

Charles Bruning Co.—8-page illustrated booklet A 1081 describes how BW Copyflex and other copying machines can both simplify and speed up paper work in all departments of business and industry.

91. Welding Alloys

Eutectic Welding Alloys Corp.—4-page illustrated bulletin EU 77 presents collection of photomicrographs that show how use of low temperature welding alloys avoids distortion, stress, warpage and embrittlement in various types of weldments.

92. Government Finishes

Glidden Co.—4-page illustrated folder "For Quick Conversion to Defense Production" tells how company is prepared to assist manufacturers who plan to or are converting to production of goods for armed services requiring government specification finishes.

93. Laminated Plastic Varnishes

Union Carbide & Carbon Corp., Bakelite Div. —42-page illustrated booklet "Laminated Plastics Made with Bakelite Phenolic Varnishes" provides fundamental facts on various grades and types of laminated plastics ranging from sheet stock to plywood crossbanding. Case histories, physical, chemical and electrical properties and methods employed in fabrication and finishing are included.

94. Piloted Type Couplings

Falk Corp.—6-page illustrated bulletin 4115 "Falk Steelflex Couplings—Piloted Type" depicts how couplings carry weight of extended shafts with no intermediate bearing support. Grid groove design provides axial and torsional flexing action under light or heavy loads, parallel or angular misalignment and free-end float. Table gives specifications and aids in selection.

95. Thin Stainless Steel

Armco Steel Corp.—4-page illustrated bulletin P. O. 7250 "Paper-Thin Stainless for Light Vital Parts" shows where stainless steel, 0.010 to 0.001-in. thick, has been used and outlines advantages resulting from use.

96. Rotary Switches

Electro Switch Corp.—8-page illustrated catalog 1950-JR contains sectional, cutaway and exploded views of rotary multipole tap and transfer switches. Application of switches in electric control circuits is facilitated by diagrams of rotor and stator assemblages and of switches with 1 to 30 sections.

97. Precision Castings

Alloy Precision Castings Co.—8-page illustrated brochure shows step-by-step production of stainless steel aircraft parts by Mercast precision casting process. Description of booking dies and advantages of process is included.

FOR MORE INFORMATION

on developments in "New Parts" and "Engineering Department" sections—or if "Helpful Literature" is desired—circle corresponding numbers on either card below

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98. Squirrel-Cage Motors

Wagner Electric Corp.—4-page illustrated bulletin MU-132 deals with type EP and JP polyphase squirrel-cage motors available in totally-enclosed fan-cooled cast iron construction for extra protection against corrosion. Type JP motors are explosionproof for Class 1 Group D hazardous locations. Both types are built in ratings from 2 to 250 hp with either normal or high-torque charcteristics.

99. Solenoid Safety Valve

Ross Operating Valve Co.—4-page illustrated bulletin 304 shows operating principle of new safety valve for industrial press and similar applications. This solenoid operated valve is designed for line pressures from 40 to 125 psi and operates whenever air or electric supply fails.

100. Synchronous Motor Controls

Electric Machinery Mfg. Co.—8-page illustrated bulletin 3100-PRD-204 contains design and application information on polarized-field frequency controls for synchronous motors. Standard interrupting capacity types are available for 25 to 3000-hp motors operating on 220 to 5000 v.

101. Strain Gages

Baldwin-Lima-Hamilton Corp.—2-page illustrated bulletin No. 174 shows graphic performance and gives specifications for ten new type SR-4 resistance wire strain gages. They are only slightly affected by temperature variations within certain ranges when bonded to steel or aluminum.

102. Rubber Parts To Order

Barr Rubber Products Co.—4-page illustrated folder details company facilities for producing molded, dipped, extruded and sponge rubber parts to specification. Wide variety of equipment, 30-year company experience and World War II record are discussed.

103. Hydraulic Standards

Miller Motor Co.—16-page illustrated "JIC Hydraulic Standards" is revised edition. Along with standards are sample circuit, glossary of terms, standard symbols, details of various types of piston and rod seals for different applications, and explanation of how Miller hydraulic cylinders meet revised JIC standards.

104. Magnetic Separators

Eriez Mfg. Co.—2-page illustrated leaflet describes three new model ATOMagnets for separating tramp iron from materials in process. Extrapower, Ultrapower and Superpower models, each in range of sizes, are made for use on wood or steel chutes, hoppers or tables. Installation data is included.

105. Aluminum Stampings

Aluminum Goods Mfg. Co.—"Present and Future" is title of book which covers facilities of this company that are available for defense work. Equipment and engineering services offered to prime contractors for supplying volume quantities of small and medium size aluminum stampings are described.

106. Inert Arc Welding

Metal & Thermit Corp.—8-page illustrated bulletin "Inert Arc Welding" explains principles and application of gas-shielded arc welding process using helium and argon. Required equipment and accessories to perform this type of welding are described.

107. Disk Type Thermostats

Stevens Mfg. Co.—2-page illustrated bulletin F-2009 deals with type M bimetal thermostats which are available in wide range of constructions and ratings and which can be supplied standard or hermetically sealed. Thermostats can be made to make or break an electrical circuit upon rise in temperature. Maximum operating temperature is 600° F.

108. Hydraulic Equipment

Vickers Inc.—16-page illustrated catalog M-5100 deals with hydraulic power packs, pumps, multiple-unit valves, steering boosters and motors designed specifically for use in mobile equipment. Typical uses of hydraulics to actuate mobile machine components are shown. Specifications are given for all types of hydraulic units.

109. Preshaped Steel Bars

A. Milne & Co.—4-page illustrated bulletin AM-100 shows many typical shapes of cold-drawn steel bar stock which is produced with special sections to fit specific purposes. Shaped bar stock can be employed in many cases to reduce or eliminate machining operations. Available steel analyses are covered briefly.

110. Variable Speed Drives

Reeves Pulley Co.—12-page illustrated bulletin G-509 describes various types of infinitely variable speed drives and control units. Three basic units in line are transmissions, Moto-drive and Vari-Speed motor pulley. All employ V-belt and variable pitch pulleys. Sectional drawings explain operation. Capacities range up to 87 hp and speed ratios from 1:1 to 16:1.

111. Cast-To-Shape Steels

Jessop Steel Co.—12-page illustrated catalog "Jessop Cast-to-Shape Steels" describes castings made from tool steels, stainless steels and heat resisting steels. Design considerations, heat treating instructions, analyses and hardness tables are included.

112. Cemented Carbide Products

Kennametal Inc.—72-page illustrated catalog 51 has specifications and prices of entire line of cemented carbide tools. Items are segregated in sections for ready reference. Information included covers recommended grades for different materials, cutting speeds for various steels, machining hints, tool wear analysis and how to design for best results from Kennametal. Characteristics of heat-resistant Kentanium and illustrations of typical wear-resistant applications are given.

113. Electrical Connector

Buchanan Electrical Products Corp.—4-page illustrated bulletin No. 750 is descriptive of various pre-SURE-connectors including splice caps and Termend lugs for stranded and solid wire. When used in conjunction with special tool, these connectors allow making completely insulated splice in three simple steps or proper wire termination in one easy operation.

114. Cellular Rubber

Sponge Rubber Products Co.—20-page illustrated brochure "Properties of and Test Data on Cellular Rubber" covers grades of sponge rubber, compression factors, influence of heat and aging, flexing, Durometer testing, heat and sound insulating values and resistance to oil and chemicals. Various specifications, tolerances and special-purpose stocks are listed also.

115. Motors & Generators

Westinghouse Electric Corp.—19-page illustrated booklet B-4595 describes new Life-Line type SK direct current motors and generators. Design features and use of cast brass brush-holders, stainless steel springs and Melamine Moldarta molded rocker rings for maximum corrosion resistance are discussed.

116. Kilovolt Meters

Hickok Electrical Instrument Co.—Illustrated data sheet on model 64 and 65 3½-in. rectangular semiflush replacement meters outlines features, including lucite window and scale length of 3¼ in. Lucite window along top edge permits external illumination. Shielded or unshielded types in most alternating and direct current ranges are available.

117. Quick-Connect Couplings

Hansen Mfg. Co.—Illustrated catalog on Quick-Connective couplings for pressure and vacuum, various fluids, pneumatic, hydraulic, oxygen, acetylene and steam service incorporates engineering data and dimensions for complete line. Also included are details of hose clamps, blow guns, sand blast cleaners and spray cleaners.

118. Hard Chrome Plater

Ward Leonard Electric Co.—4-page illustrated bulletin IC-20 describes model A-20 Chromaster industrial hard chrome plating unit. This bench model features built-in power supply and is self-contained. Rated 20 amperes, equipment will plate maximum surface of 10 sq in. at 2-amp per sq in. current density, and rate of deposition is constant at 0.002-in. per hour.

119. Tension Linkages

Chain Belt Co., Baldwin Duckworth Div.—Illustrated handbook for designers of tension linkages deals with chain in which linear motion is not continuous in direction. This bulletin 51-10 contains examples of applications, plus information on various types of roller chains used in such linkages. Predominating feature of tension linkage is that chain need not be endless belt.

120. Packings

Greene, Tweed & Co.—16-page illustrated catalog PC-101 details application, structure and performance for Palmetto self-lubricating, molded and sheet packings, both standard and special. Packings for piston rings and piston pumps are included, along with application and selection charts and specification tables.

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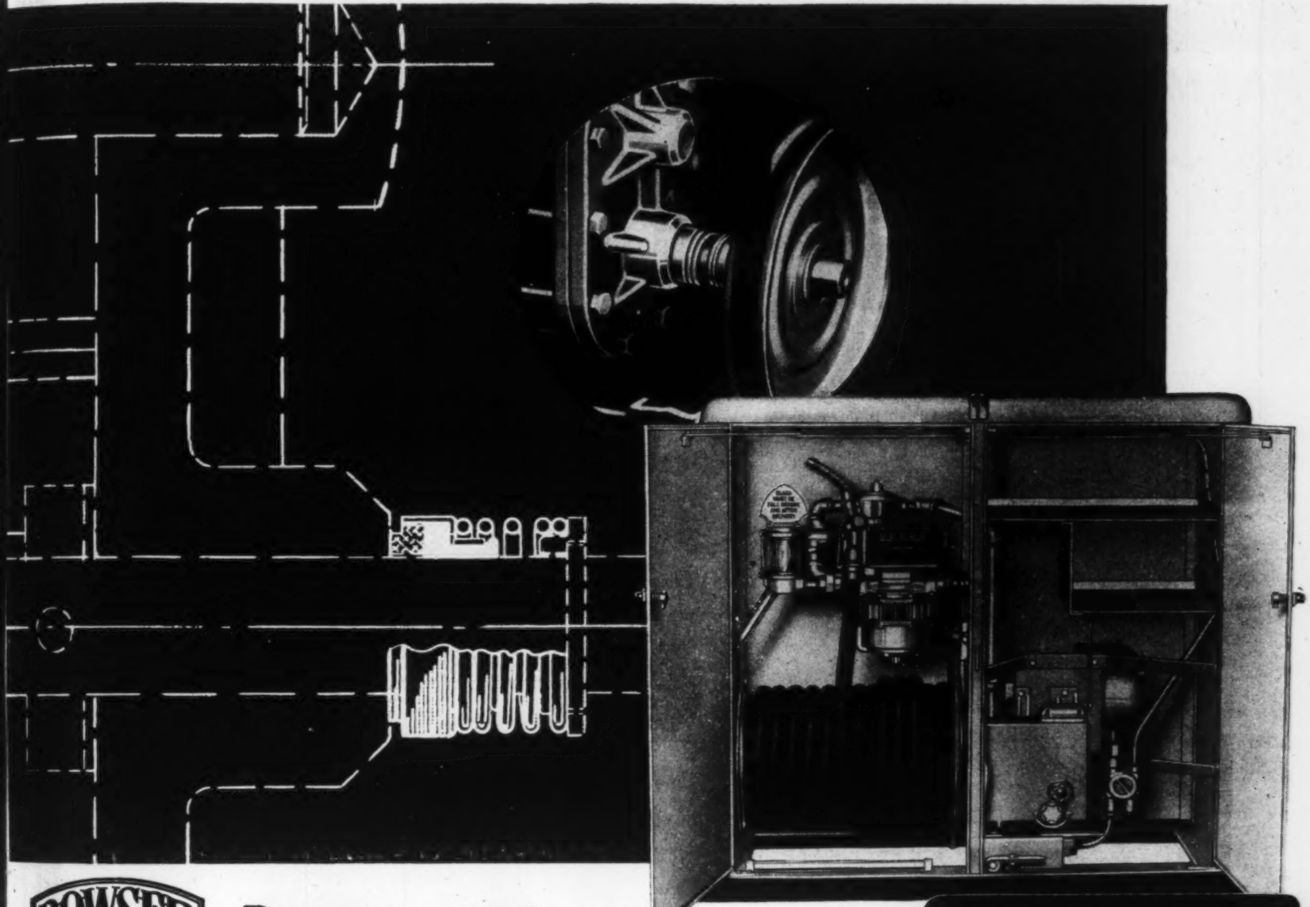

BOWSER Pumps get *Shaft-Sealing Certainty* with ROTARY SEALS

"Bowser" is a big name in gasoline pumps, as befits the originators of those important devices. Like all industrial leaders, they are properly jealous of the reputation their equipment holds for top efficiency and freedom from mechanical breakdown. Every detail of construction must be designed to stand up to hard, hour-after-hour use under all kinds of conditions. Trouble with Shaft Sealing could be an expensive nuisance—but here's a quotation from one of Bowser's descriptive circulars:

> "THE FINEST OF PUMPING UNITS . . quiet, trouble-free operation. There's no packing to wear out or cause shaft wear . . no binding or drag . . no high power costs — because BOWSER Pumps are equipped with the modern Rotary Seal."

You'll find many applications of Rotary Seals in Bowser's line, the most diversified in the field—and likewise, in their well-known filters for cleaning establishments and similar uses. ROTARY SEAL engineers will be glad to consult on *your* Sealing problems, placing at your service years of success in developing just the right Seal for all kinds of applications in many fields. Call us in at the drawing board stage, if possible—our experience can often suggest the way to simpler and better design through tested approaches to the Shaft Sealing problem.

THE ROTARY SEAL PRINCIPLE

Sealing
Certainty
of rotating shafts

is the original approach to a practical solution of a universally troublesome problem. Our booklet "SEALING WITH CERTAINTY" explains and illustrates the principle. We're glad to send it to you without obligation.

THE ROTARY SEAL COMPANY

mechanical seals for rotating shafts

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KUP®

synthetic composition
or otherwise
always tailored to the performance you specify

Service conditions or cost factors commonly suggest selection of Kup packing of *synthetic* composition. At such times count on Palmetto *synthetic* Kup for the same top performance that characterizes Palmetto's *fabric bonded* Kup . . . the same Palmetto factors are at work for longer life, less downtime on all air or hydraulically operated equipment.

Personalized Capacity . . . the composition of every Kup is a "special", developed as a perfect match to the service condition—the temperature, pressure, motion, speed or fluid handled. No "off-the-shelf" answers in filling even standard cup packing needs.

Special Palmetto Compounds and Lubricants . . . "on-the-scene" familiarity with service conditions and packing requirements have led to the development of Palmetto extras such as lubricants which, when mixed with the compound, reduce packing friction to a minimum, enable Kup to withstand heat or long shutdown periods without "drying out", or requiring maintenance lubrication. Research and "know how" equip every Kup for the special performance that pays off in special services.

Complete Manufacturing Responsibility from start to finish, Palmetto Kup is the product of its manufacturer, even to the design and manufacture of the mold—an assurance to you of accuracy and satisfaction, and moderate tooling charges, too.

PALMETTO *Packings*

Write for Bulletin MP-20—for complete facts on Palmetto Kup. Write for Bulletin PC-101 for details on all Palmetto packings for all industry.

packing more performance into every application

GREENE, TWEED & CO.
NORTH WALES • PENNSYLVANIA

MEN OF MACHINES

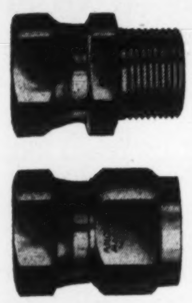
Rodney F. Lauer

Rodney F. Lauer has been named vice president in charge of engineering and research by York Corporation, York, Pa. Mr. Lauer, who has been with the air conditioning and refrigeration firm since he received his degree in mechanical engineering at Cornell University in 1930, had been managing York's Pacific district since 1944. During World War II, he engineered the first combination "strato" chamber and all-weather room for the U. S. Navy, and has since played a major role in the devolopment of similar projects for the Armed Services. When a highly sensitive air conditioning plant was needed during the war for the manufacture of radar and television tubes, Mr. Lauer was given the task of engineering the system, which at the time was regarded as one of the most difficult problems in the air conditioning and refrigeration industry.

◆

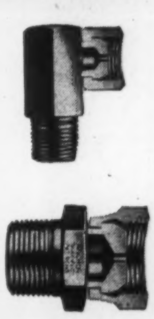
Everett A. Utecht

Appointment of **Everett A. Utecht** as assistant chief engineer, Davey Compressor Co., Kent, O., was announced recently. Mr. Utecht has been a member of the Davey engineering staff for the past five years. A mechanical engineering graduate of the University of Wisconsin, he was an engineer in the U. S. Navy, Bureau of Ships, during World

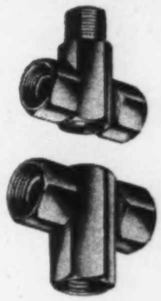


Straight Adapter Unions

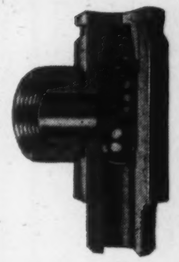
45° and 90° Adapter Unions



Restricting Adapter Unions

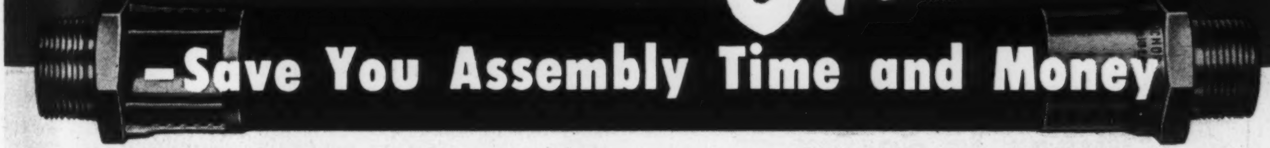


Tees

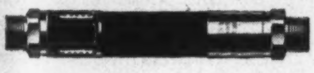


90° Check Valve Union

ANCHOR Adapter Unions



—Save You Assembly Time and Money



Anchor Ductile Sleeve Couplings assembled on two wire braid hose for high pressures.

Anchor Sleeveless Couplings assembled on either single wire braid hose or two rayon braid hose for medium or low pressures.

Anchor Clamp-type Couplings are ideal for field service use and emergency repairs. Easy to put on and take off—withstand high pressures.

Use Anchor Assembled Hose Units with the outstanding fittings shown above. You'll have less trouble in the shop on assembly — and less trouble in the field on the job.

Time is money. And whenever you save time, you reduce costs.

That's why it pays to use Anchor Adapter Unions and Related Fittings. You see, they're designed especially to speed the attachment of Anchor hydraulic hose assemblies to equipment of all kinds.

In addition to cutting assembly costs, Anchor Adapter Unions and Fittings have these important advantages:

- They provide a leakproof ground-joint connection.
- They are small in size, require little space, and provide a neat appearance.
- You can connect and disconnect them many times without destroying the seal.
- Made from solid steel bar stock and plated to prevent rust, they stand up under the toughest service conditions.
- Their use lets you eliminate one or more pipe-thread joints—gives you a better piping job.
- Assembly in confined spaces is quicker and easier.

The Anchor line of Adapter Unions and Related Fittings is the most complete line available. Save yourself time and money—select those that fill your specific needs.

Send for complete information on Anchor Adapter Unions and Fittings

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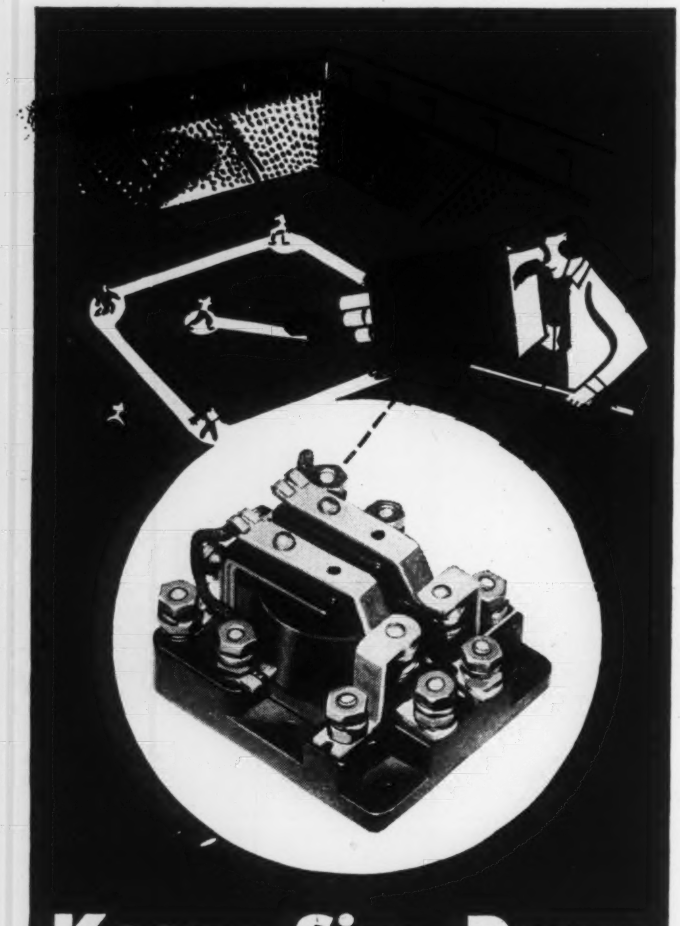


Keeps Size Down

by keeping one jump ahead in design

The smaller the equipment—the more trouble from high inrush currents . . .

This portable telecast equipment first used a single pole supply line relay—but the high inrush currents the instant after closing, sometimes welded the contacts. Solution appeared to be to use a larger relay or to alter the equipment, increasing its size.

Then: Ward Leonard suggested a *heavy-duty midget* parallel contact relay—no larger than before—with poles paralleled and with silver-to-carbon contacts on one pole making contact before the silver-to-silver contacts close on the other pole.

Investigate Ward Leonard facilities for *variations* of standard designs to simplify your control.

WARD LEONARD ELECTRIC CO., 58 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD
ELECTRIC COMPANY
Result-Engineered Controls
RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES
W L

War II and previous to that was affiliated with U. S. Gypsum Co., Chicago, and Steel Improvement & Forge Co., Cleveland. In his new position, Mr. Utecht will be in charge of the design and engineering of both new and standard line Davey air products.

◆

Formerly manager of the Engineering Physics Division of Frederic Flader Inc., **G. O. Haglund** has been named assistant director of General Mills Aeronautical Research Laboratories, Minneapolis. He will be responsible for operating procedures, practices and administration of the company's aeronautical research organization. Mr. Haglund has served as assistant engineer with the Allis-Chalmers Manufacturing Co., project engineer for the Naval Ordnance Laboratory and head of the Instrument Section of the Physics Department, Curtiss Wright and Cornell Aeronautical Research Laboratories. With Frederic Flader Inc. he was active in research and development work for the Atomic Energy Commission and U. S. Air Force.

◆

Having served as chief engineer since 1947, **Robert J. Stoddard** has been elected vice president of engineering for American Hoist & Derrick Co., St. Paul.

◆

John T. Lancaster has joined Conner Tool & Cutter Co., Detroit, as works manager. He will handle all production operations for the two Detroit plants of the company, which serves hundreds of major manufacturers as deep hole and boring specialists.

◆

Because of expansion of the company's activities into the fields of basic and aircraft instrumentation, several additions have been made to the engineering staff of the Cook Research Laboratories, Chicago. One of the most recent staff additions is **Dr. Joseph F. Zeichmeister,** who will fill the position of assistant chief engineer. For the past 13 years, Dr. Zeichmeister has been associated with the Gaertner Scientific Corp. of Chicago as a physicist and engineer.

◆

Dr. George H. Lee, one of the foremost authorities on photoelastic methods of studying metals under stress, will join the faculty of Rensselaer Polytechnic Institute on July 1 as professor of mechanics. Dr. Lee comes to Rensselaer from Annapolis where he has been teaching since 1945 in the United States Naval Postgraduate School.

◆

Appointment of **Emory W. Worthington** as vice president in charge of mechanical development was announced recently by Bjorksten Research Laboratories Inc. He will make his headquarters at the Madison, Wis., office of the company and will visit the Chicago and New York offices regularly, devoting himself initially to developing application of reinforced plastics to fast-moving machine parts. Mr. Worthington was vice president and chief engineer of Babcock Printing Press Corp. of Canton, O., from July, 1949, to October, 1950, and before that was chief engineer for the Champlain Co. Inc. of Bloomfield, N. J. For 12 years he was associated with the Goss Printing Press Co. of Chicago in various engineering positions, the last of which was chief development engineer.

◆

Raymond H. Schaefer has been elected a vice president of American Brake Shoe Co., New York. He joined the company in 1940 and was appointed director of research and development in 1947. He will continue in charge of the research activities of the company.

◆

Louis Soltanoff has joined Martin & Schwartz, Salisbury, Md., as a design engineer. Prior to this post, Mr. Soltanoff was chief engineer of American Hydrovac Inc., Brooklyn, N. Y., for several years. In his new position he will be directly concerned with the design and testing of small, precision hydraulic mechanisms.

◆

Electrol Inc., Kingston, N. Y., manufacturer of aircraft and industrial hydraulic devices, has announced the appointment of **Vic N. Thacker** as production manager. Mr. Thacker was formerly associated with Fairchild Aircraft as equipment engineer.

◆

Robert T. Eakin, who joined Allegheny Ludlum Steel Corp. as a student trainee in 1940, has been appointed manager of the company's largest plant, in Brackenridge, Pa. He succeeds **George Evans,** who becomes special consultant to the vice president in charge of operations.

◆

Ross J. Martin, associate professor of mechanical engineering, has been named associate director of the University of Illinois Engineering Experiment Station. He will serve under Dean William L. Everitt, who is also director of the Station, as liaison man between the Station and agencies sponsoring many of its investigations.

◆

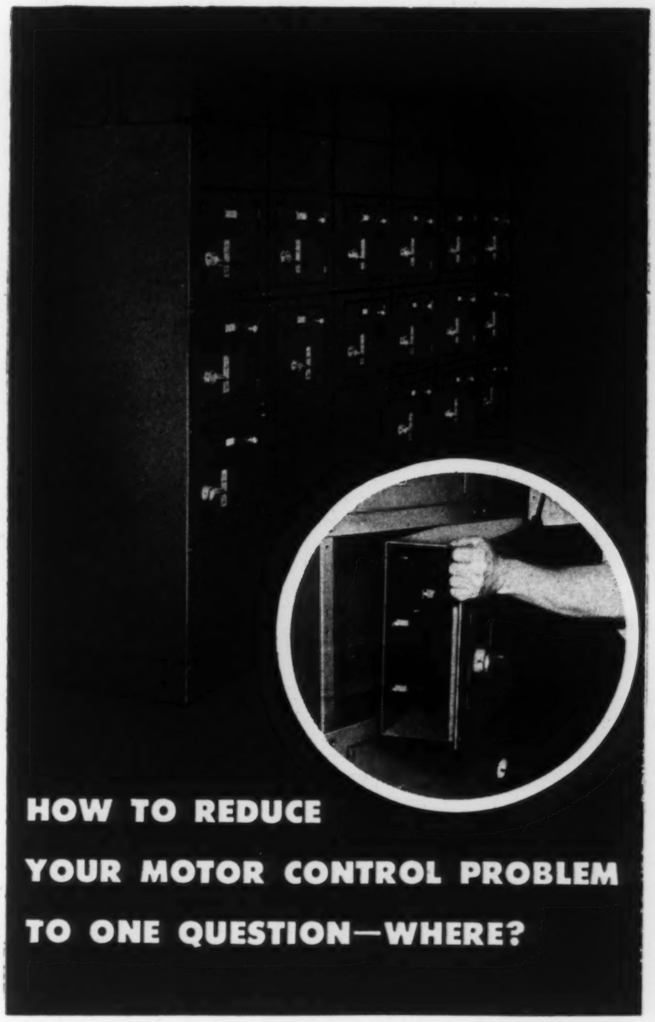
K. O. William Sandberg of the General Electric Company's Chemical Department has been appointed manager of the firm's industrial engineering section.

◆

Former chief engineer, NEPA project, **Andrew Kalitinsky** has been appointed by M. W. Kellogg Co., New York, as manager of its special projects departmetn. This department is concerned with research and development of rockets and rocket motors for the U. S. Air Force and Navy.

◆

W. J. Phillips, who was formerly associated with the Steel Founders' Society of America, has joined Crucible Steel Casting Co., Cleveland, as chief engineer. Previous to his affiliation with the Steel Founders' Society, he served as president of Phillips Foundry Co. of Bakersfield, Calif., a firm which he helped organize.



"Building-block" units permit grouping all motor controls at one point

You control *all* the motors in an entire area, floor or building—when you *centralize* the controls with Ward Leonard MULTITROL*.

Prefabricated MULTITROL units (each a complete control for one motor) fit into standard framework in any arrangement to suit the space. Units can be added, subtracted, interchanged, or relocated.

Some of the problems MULTITROL solves include: *Structural framework*—none needed, MULTITROL units are free-standing. *Obstructions*—no difficult cable or pipe forming, no chopping out walls. *Appearance*—no haphazard box mounting. *Safety*—completely deadfront construction.

Investigate MULTITROL. Wide choice of starter types, combined with externally-operated thermal circuit breakers. Write for Bulletin 4410. WARD LEONARD ELECTRIC CO., 58 South Street, Mount Vernon, N.Y. Offices in principal cities of U. S. and Canada.

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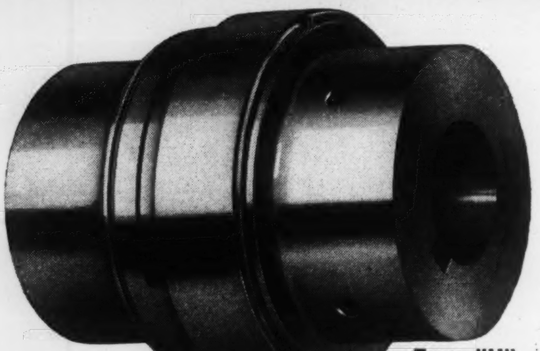

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LASTS LONGER. . .
RUNS SMOOTHER!

Here's Why!

These simple, sturdy couplings compensate for MISALIGNMENT, VIBRATION, STARTING, TORQUE, BACK-LASH, WHIP, SHOCK, SURGE.

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THE ENGINEER'S Library

Servomechanisms and Regulating System Design
Volume I

By Harold Chestnut and Robert W. Mayer, both of the aeronautics and ordnance systems divisions of the General Electric Co.; published by John Wiley & Sons Inc., New York; 505 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$7.75 postpaid.*

Achieving a high accuracy and a high degree of stability in a feedback control system (closed loop servomechanism) without increasing complexity and cost is a problem which the designer is asked to solve in this day when the trend is toward greater automatic control of engineering equipment. The design engineer must have available the methods of synthesis and analysis of feedback systems in order to have his process strike the optimum balance between performance and cost. Written as one of a series in the interest of the advanced course in engineering of General Electric Co., this book presents these methods to the design engineer.

The book starts from the basic mathematics, describes clearly the nature of the physical problems involved, and proceeds to the solution of advanced designs. Distinctive features of the book are: emphasis on the feedback control concept for regulators and servomechanisms; presentation of both the differential equation and Laplace transform methods of solving transient problems; development of building blocks for mechanical, electrical, hydraulic, and steering transfer functions; emphasis on the attenuation concept for regulators and servos; and the stress on the practical approach to system synthesis. Included are charts indicating the nature of design characteristics necessary to obtain desirable steady-state and transient responses. Numerous problems illustrate and extend the text.

□ □ □

Machinability and Machining of Metals

By Norman E. Woldman, consulting metallurgical engineer, and Robert C. Gibbons, metallurgical engineer, Eclipse Pioneer Div. of Bendix Aviation Corp.; published by McGraw-Hill Book Co., New York; 518 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$7.50 postpaid.*

An important consideration in the selection of a metal for incorporation into a design is the ease with which the metal can be converted into the finished

American Offers FELTS TO ARMED FORCES SPECIFICATIONS

If you have Defense Order Contracts, or subcontracts calling for the use of wool felt, get in touch with American. We can supply you with the felt to meet your specifications.

When writing, please use these felt specification numbers on your contracts.

This information is important, since in recent years there have been changes in Federal specifications for wool felts. American knows and will gladly work closely with you to see that Defense Orders for felt are filled with material that meets the requirements exactly.

Note These Specifications

Here are the three most important current specifications for wool felt.

Specification No.	**Title**
Federal Specification C-F-206 (Identical with S.A.E. Felt Specifications)	*Felt Mechanical Roll*
Quartermaster Contracts *MIL-F-10954 (Supersedes 8-15G)*	*Wool Felt*
Air Force Contracts *MIL-F-5656 (Supersedes AN-F-14a) (Identical with S.A.E. Felt Specifications)*	*Felt Wool*

American Felt Company

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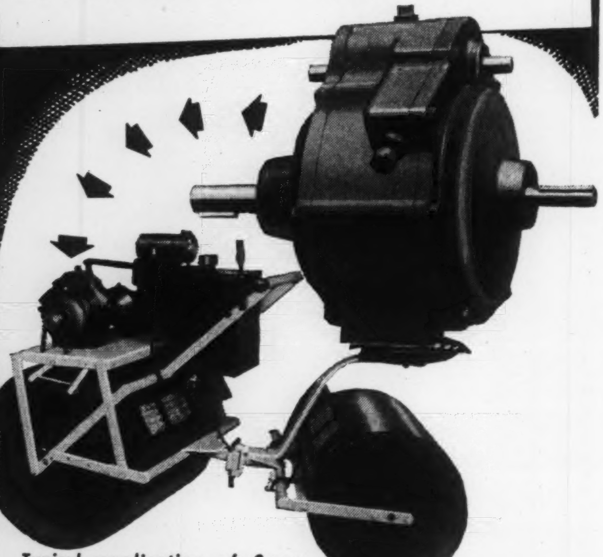
ENGINEERING AND RESEARCH LABORATORIES: Glenville, Conn.—PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I.—SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Dallas, San Francisco, Los Angeles, Portland, Seattle, Montreal.

Amazing **NEW**

REVERSING TRANSMISSION

Solves Numerous Design Problems



Typical application of Snow-Nabstedt Reversing Transmission by Gabb Mfg. Co., Windsor Locks, Conn. on its "Motoroller".

- SO UNIQUE — One unit combines forward, neutral, reverse and reduction . . . no separate clutch required! Has coaxial input-output shafts.
- AMAZING PERFORMANCE — Reverses occasionally, or frequently, under full load, without hesitation! Transmits 2 to 12 H.P. with 3.75: 1 reduction in both directions.
- HAS MANY APPLICATIONS — Suits design needs of machine tools, construction, agricultural, and materials handling equipment.
- REDUCES MAINTENANCE — is adjusted externally, without dismantling! Its pinions can't overheat; are long-lived.
- SAVES MONEY — Eliminates separate gear box, clutch, countershaft and mounting brackets in many applications. *SAVES assembly time, servicing problems, and improves product appearance.*
- SAVES SPACE — The most compact transmission available . . . only 9-1/16" x 8" x 9-1/2".
- QUALITY-ENGINEERED—Designed by makers of Joe's Famous Gears, world-renown for 46 years. Have our capable engineers produce transmissions to serve your defense equipment needs!

WRITE TO-DAY for descriptive bulletin or specify your needs, stating application, input and output speeds desired, H.P., power source, equipment to be driven.

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product by machining. This book provides a guide to materials selection by presenting the general principles of machining metals, the metallurgical characteristics of the materials which offer various mechanical and thermal treatments, and also the types and compositions of cutting tools to be used.

In general, discussions of the particular metals begin with the consideration of their metallurgy and proceed with the pertinent factors relating to their machinability and machining. Each chapter deals with a specific type of metal. Covered are: low-carbon steels, high-carbon steels, alloy steels, tool and die steels, stainless steels, and cast irons, as well as alloys of aluminum, magnesium, copper, nickel, zinc, and special metals. Because nonmetallics such as hard rubber and plastics are also machined commercially, a chapter on these materials is included. Principles and mathematics of machining are presented in the opening chapters; a comprehensive chapter on cutting fluids is also included. An appendix of permanent reference value contains nomograms, tables and charts on steel properties, cutting speeds and feeds, thrust loads in drilling, etc.

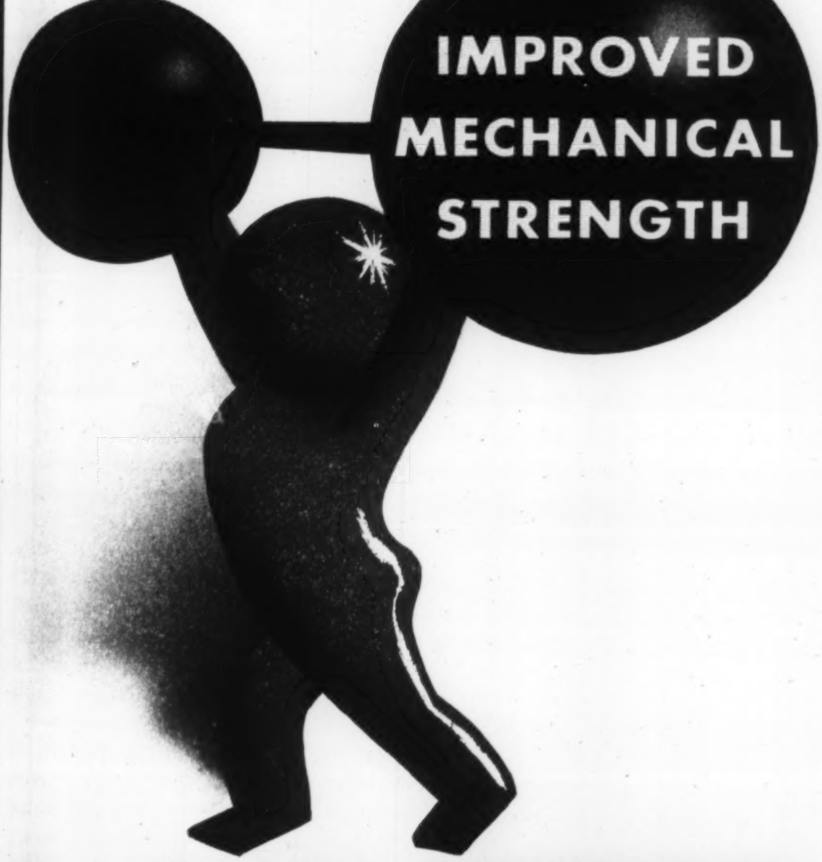
The approach to the subject is both theoretical and practical. Theories and conclusions are based on laboratory experiments and actual production.

Manufacturer Publications

Mechanical Fastening Methods for Aluminum: Eight main sections of this book discuss standard rivets, special rivets, standard screw fasteners, special screw fasteners, nails and pins, metal stitching, mechanically formed joints, and resin bonding. Included in the 17 tables of data are dimensions and number of pieces per pound for six different types of standard rivets, lengths of rivets for cone-point and button type driven heads, recommended hole sizes with shear and bearing area for both hot and cold-driven rivets, and maximum loads for single rivets in shear. Trade names of special screw fasteners and their manufacturers are listed. Nominal chemical compositions and typical mechanical properties of wrought aluminum alloys as well as typical tensile and bearing properties of aluminum alloy plates and shapes are included together with dimensions for standard aluminum spring lock washers. An additional table lists recommended interference fits for cast iron and steel bushings in aluminum at room temperature. This 136-page, wirebound booklet may be obtained by directing company-letterhead requests to Reynolds Metals Co., 2500 South Third St., Louisville 1, Ky.

Principles of Centerless Grinding—G-503-2: Opening with a concise discussion of the basic principles of centerless grinding, this book continues with a rather comprehensive treatment of the methods, advantages, operating controls, and construction details of this metal processing technique. Selection of blade and wheel materials, truing the wheels, and thrufeed and infeed corrective adjustments are also discussed. Several pages are devoted to the economy of centerless

HOW YOU PROFIT FROM G-E SILICONE RUBBER'S IMPROVED MECHANICAL STRENGTH



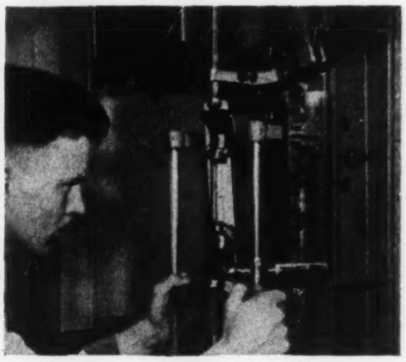
Parts fabricated by General Electric from its new, improved silicone rubber (G-E 12650) combine remarkable mechanical strength with extraordinary thermal and electrical properties. G-E silicone rubber parts possess high tensile strength, high elongation and tear strength. Serviceable over a temperature range of –85 to 500 F, this new silicone rubber makes parts heretofore impractical with other silicone rubbers.

DEPEND ON G. E.

General Electric's *specialized* fabricating service is ideally equipped to supply the silicone rubber parts you need. This specialized service fabricates *only* silicone rubber compounds—your assurance of high-quality parts uncontaminated with other materials. Special molding and extruding techniques are employed, using G. E.'s own quality-controlled compounds, or any commercially available compound specified by a customer. General Electric, a pioneer in the development of silicone rubber, has tremendous "know-how" gained through designing hundreds of applications. Put this *specialized* fabricating service to work for *you!**

**Address inquiries to Section F-3, Chemical Department, General Electric Company, Pittsfield, Massachusetts.*

Design engineers can now use G-E silicone rubber for gaskets, brake boots, valve diaphragms and vibration mounts.



Elongation test shows that the new G-E silicone rubber is 100 to 150% stronger than former G-E silicone rubbers.

DEPEND ON G. E.'S SPECIALIZED FABRICATING SERVICE

GENERAL ELECTRIC

grinding of small lots primarily to dismiss the opinion that the method is exclusively adapted to mass-production. Tables, useful for production estimating present thrufeed traverse rate data.

Copies of the 48-page booklet may be obtained from the Cincinnati Milling Machine Co., Cincinnati 9, O.

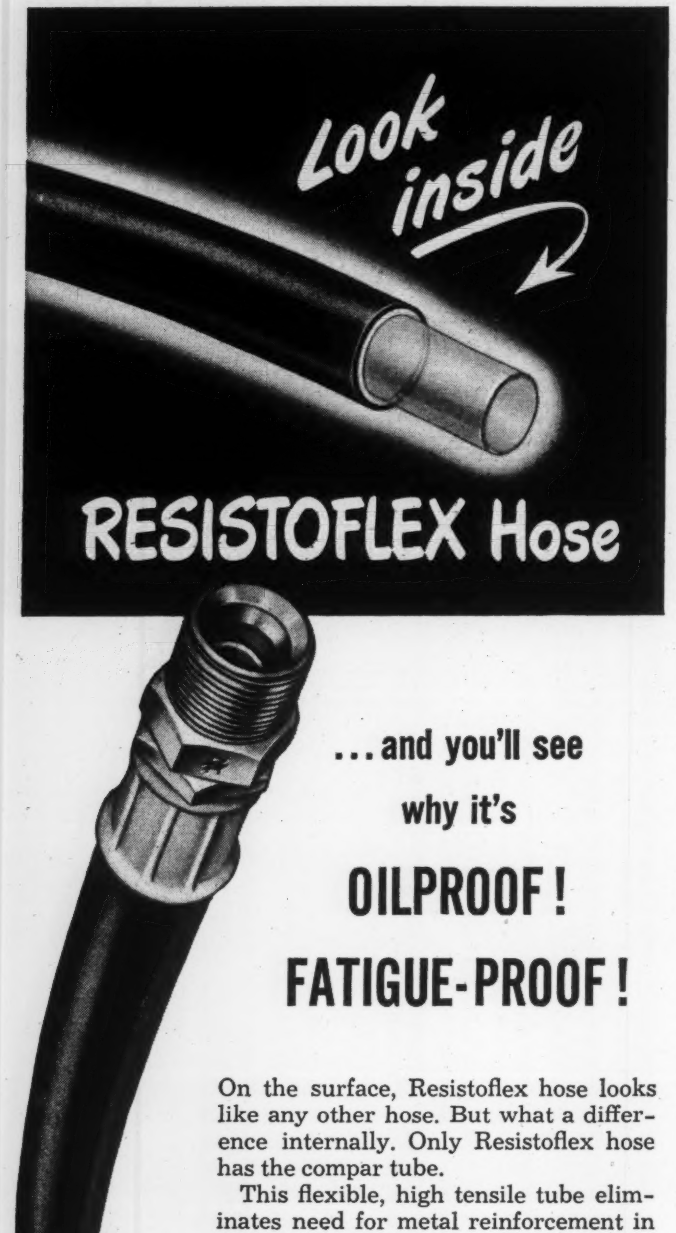
Government Publications

Electronic Equipment Construction—New Objectives, New Techniques, New Components—PB 101 745: This report, prepared by the Stanford Research Institute under contract to the Office of Naval Research, consists of three parts: a description and evaluation of new components; a discussion of new construction techniques; and a survey of research at 62 of the nation's leading electronics development firms and laboratories. Components covered in detail include fixed and variable resistors, fixed and variable capacitors, high-frequency inductors and transformers, multiple-component units, vacuum tubes, crystals and transistors, frequency-control and transducer devices, power and audio transformers, relays, indicating instruments, connectors, tube sockets, batteries, motors and servomechanisms, insulating materials, switches, and hermetic seals. New techniques receiving special attention include printed circuits and conductor patterns, mechanized construction, unitized construction, hermetic sealing methods, cast resin embedment, and heat removal techniques. Of particular interest is a special section in which the current research and development needs of the electronics field are summarized by the authors under these principal headings: reliability; heat and high-temperature resistance; better packaging; miniaturization; and improved manufacturing and mechanization techniques.

Copies of the 300-page, 8½ by 11-inch, paperbound book may be obtained from: Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. Price per copy is $7.00; check or money orders are payable to the Treasurer of the United States.

Exposure Tests on Galvanized-Steel-Stitched Aluminum Alloys—NACA TN 2299 by Fred M. Reinhart: Sheets of 24S-T3 and alclad 24S-T3 aluminum alloys joined by stitching with galvanized steel wire were exposed in a marine atmosphere and in the tidewater to determine whether they would have a satisfactory service life in these environments. Both alloys joined by this method are satisfactory with respect to corrosion resistance for service in marine atmospheres. The alclad 24S-T3 alloy is satisfactory for short periods of time where the installation is subject to frequent wetting by sea water. The use of 24S-T3 sheet joined by stitching with galvanized wire is not satisfactory when subjected to wetting by sea water.

Copies of this report may be obtained from the National Advisory Committee for Aeronautics, 1724 F St., NW, Washington 25, D. C.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For out of the ordinary engineering with synthetics
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On the surface, Resistoflex hose looks like any other hose. But what a difference internally. Only Resistoflex hose has the compar tube.

This flexible, high tensile tube eliminates need for metal reinforcement in medium pressure hydraulic applications. It also makes the hose *impervious* to oil. Result: No erosion, no gumming, no clogging. And no fatigue under constant flexing conditions.

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WEATHER RESISTANT STOCKS

	Before Aging				After Aging (* = 70 hrs. @ 212° F.) († = 70 hrs. @ 158° F.)		
STOCK NUMBER	DUROMETER HARDNESS Shore A Scale	TENSILE STRENGTH p.s.i.	ELONGATION per cent	LOW TEMP. °F. (5 hr. test)	DUROMETER HARDNESS Shore A Scale	TENSILE STRENGTH p.s.i.	ELONGATION per cent
408	60	2233	550	−70	†56	1951	475
507	65	2418	360	−70	†68	2544	325
526	58	2855	420	−70	†60	2997	400
566	78	1546	250	−70	†84	1706	215
720	60	2284	500	−50	*80	1953	228
822	65	2285	350	−50	*62	2239	433
823	80	2081	235	−50	*82	2016	175
847	50	1569	548	−50	*60	2000	338

*A.S.T.M. D746-44T

Stocks listed above are only representative of the many compounds available.

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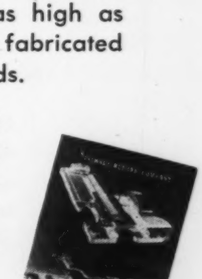
Featuring resistance to sunlight, ozone, freezing temperatures and salt air, STALWART-compounded weather-resistant rubber stocks are available in mass produced parts for application in aircraft, automobiles, trucks, marine equipment, electrical assemblies and railroad rolling stock.

Whether they are to withstand dry desert heat and burning sunlight or the prolonged damp cold of artic regions, these newly developed rubber stocks can be supplied in precision molded, extruded, die-cut, or lathe-cut shapes having varying degrees of hardness, tensile strength and elongation to meet the demands of specific applications.

In addition to weather resistance, these parts can have the capacity for withstanding other deteriorating forces such as abrasion, compression and chemical action. For applications involving extreme temperatures as low as —110° and as high as +500° Fahrenheit, parts can be fabricated from Silicone Rubber Compounds.

STALWART is prepared to meet individual requirements as well as S.A.E. and A.S.T.M. specifications. Write today for the new 16-page illustrated catalog No. 51SR-1.



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STALWART RUBBER COMPANY

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How a Pittsburgh Brush Solved an Oil Pressure Problem*

*** An actual case history from the Allis-Chalmers Pittsburgh Works, manufacturers of Transformer Radiators.**

At Allis-Chalmers, well-known manufacturer of industrial equipment, the problem was to secure a satisfactory oil pressure test on transformer radiators. The key to the problem was to find a brush narrow enough to clean between cooling fins and strong enough to remove slag and spall on welds which could conceal pinholes. Pittsburgh engineers recommended an 8″ rotary wire brush. The brush proved more than satisfactory and the problem was solved!

Let Pittsburgh Engineers Solve Your Brush Problems.

Pittsburgh's complete line of brushes of every type, for every purpose, will provide a practical and economical solution of any brush problem you might have. Drop us a line on your company letterhead for a copy of our new booklet that shows, through actual case histories, how Pittsburgh can help cut your brushing operation costs. Address: PITTSBURGH PLATE GLASS COMPANY, *Brush Div.*, Dept. W1, 3221 Frederick Ave., Baltimore 29, Md.

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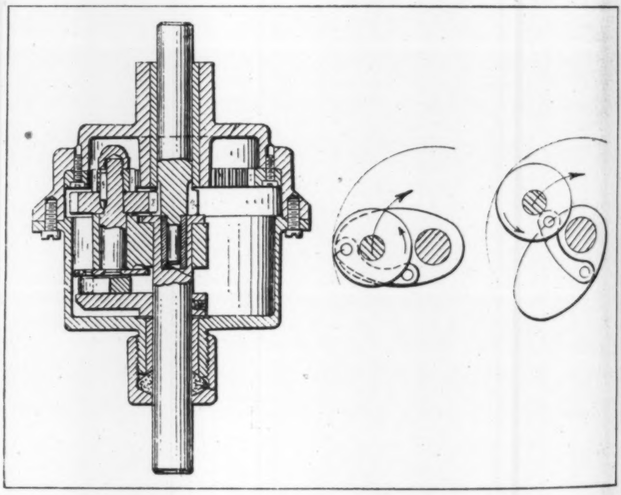
NOTEWORTHY
Patents

INTERMITTENT ROTATION from a constant-speed rotary input motion can be obtained through a planetary gearset and a crank and link arrangement. The intermittent rotary-oscillatory output is well suited to operations such as honing and lapping. A compound planetary pinion is driven around an internal ring gear on the stationary housing by a sun gear on the input shaft. This planetary pinion rotates a crank linked to another crank on the output shaft. Rotation of the pinion crank about the pinion axis, together with travel of the pinion crank about the output shaft axis, imparts a rotary-oscillatory motion to the output shaft. Frequency of the repetition of the reversal pattern is controlled by the ratio of teeth on the pinion and on its meshing ring gear. For example, a ratio of 11 to 48 gives 48 motion reversals before they again occur at the same point in the revolution of the output shaft. The patent, No. 2,538,620, has been assigned to Metal Seal and Products Inc. by August H. Heinrich.



WIRE TENSIONING in coil winding operations is accomplished without detrimental cold working of the wire with the device covered in patent 2,534,130. The wire is given 1¼ turns around a spokeless, grooved wheel or ring rotating on internal rollers. One of these rollers is carried on a pivoted, spring-loaded arm on which a tensioning pulley is also mounted. If the wire starts to slack, the spring tends to pivot the arm and increases pressure of the use

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To: **SAVE WEIGHT**
GAIN STRENGTH
REDUCE COSTS

Made by the revolutionary reverse-draw process, Scaife deep-drawn metal shapes have the improved physical properties, desirable uniformity of wall thickness and other characteristics that are important in reducing weight and increasing strength. The process is ideal for pressure vessels, for other deep-drawn shapes such as rocket and missile bodies and tubes, and for a great variety of containers and enclosures. A brief description of the process is given below. Scaife engineers will be glad to work with manufacturers using or planning to use deep-drawn shapes.

Starting with a circular sheet of steel—

a cup is formed by a conventional drawing operation.

A continuation of this pressing operation turns the cup "inside out" without removing it from the dies—

completing—in a single stroke—a deep-drawn shape having remarkably uniform wall thickness.

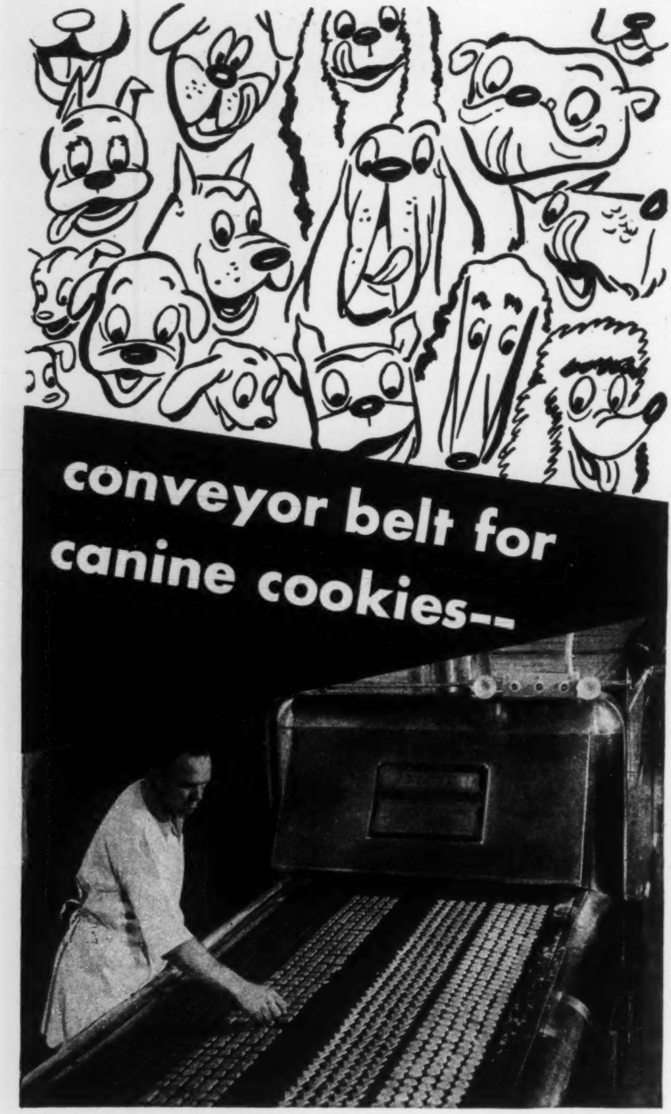
The Scaife Reverse-Draw process is suitable for the production of shapes having cross-sections that are circular, oval or rectangular. They can be made with one end completely closed and with the other end flanged or straight. Shapes up to 36 inches maximum diameter can be formed of ferrous and non-ferrous materials, with wall thicknesses up to ¼ inch.

FOUNDED 1802

Scaife Company

[illegible] PITTSBURGH DISTRICT, PA.

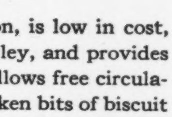
Makers of Pressure Vessels for Air, Gases, Liquids


conveyor belt for canine cookies--

Imagine your dog's delight on seeing a solid column of biscuits 160′ long and 42″ wide! That's the carrying surface of this Cambridge Woven Wire Conveyor Belt in a recirculating oven at Kendall Foods Company, Bell Gardens, California.

Balanced Weave, specified for this installation, is low in cost, eliminates creeping of the belt on the drive pulley, and provides high tensile strength. Open mesh of the belt allows free circulation of heat within the oven . . . crumbs and broken bits of biscuit fall through the belt, cannot foul up automatic packaging equipment at the end of the oven.

Whether you're baking biscuits, processing meat or canning vegetables, there's a Cambridge Woven Wire Conveyor Belt to help mechanize your production. Stainless steel to meet sanitary codes is a standard material of construction for our food plant customers. Call in your Cambridge field engineer today, let him explain the superior construction features of **Cambridge Woven Wire Conveyor Belts . . .**



The Cambridge Wire Cloth Co.
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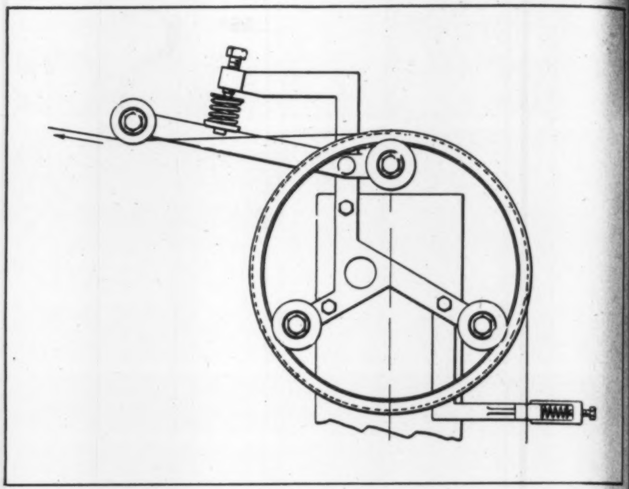
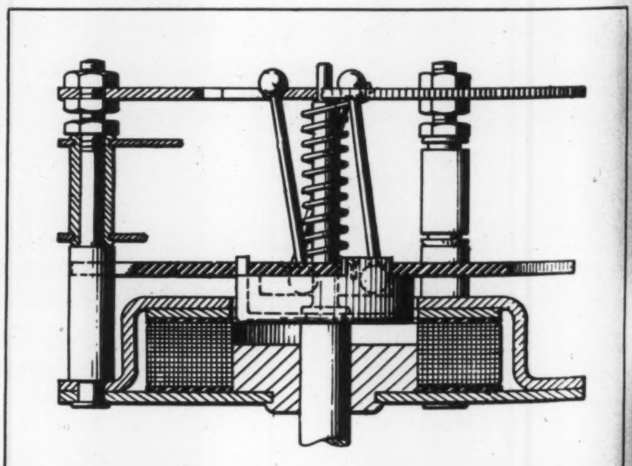
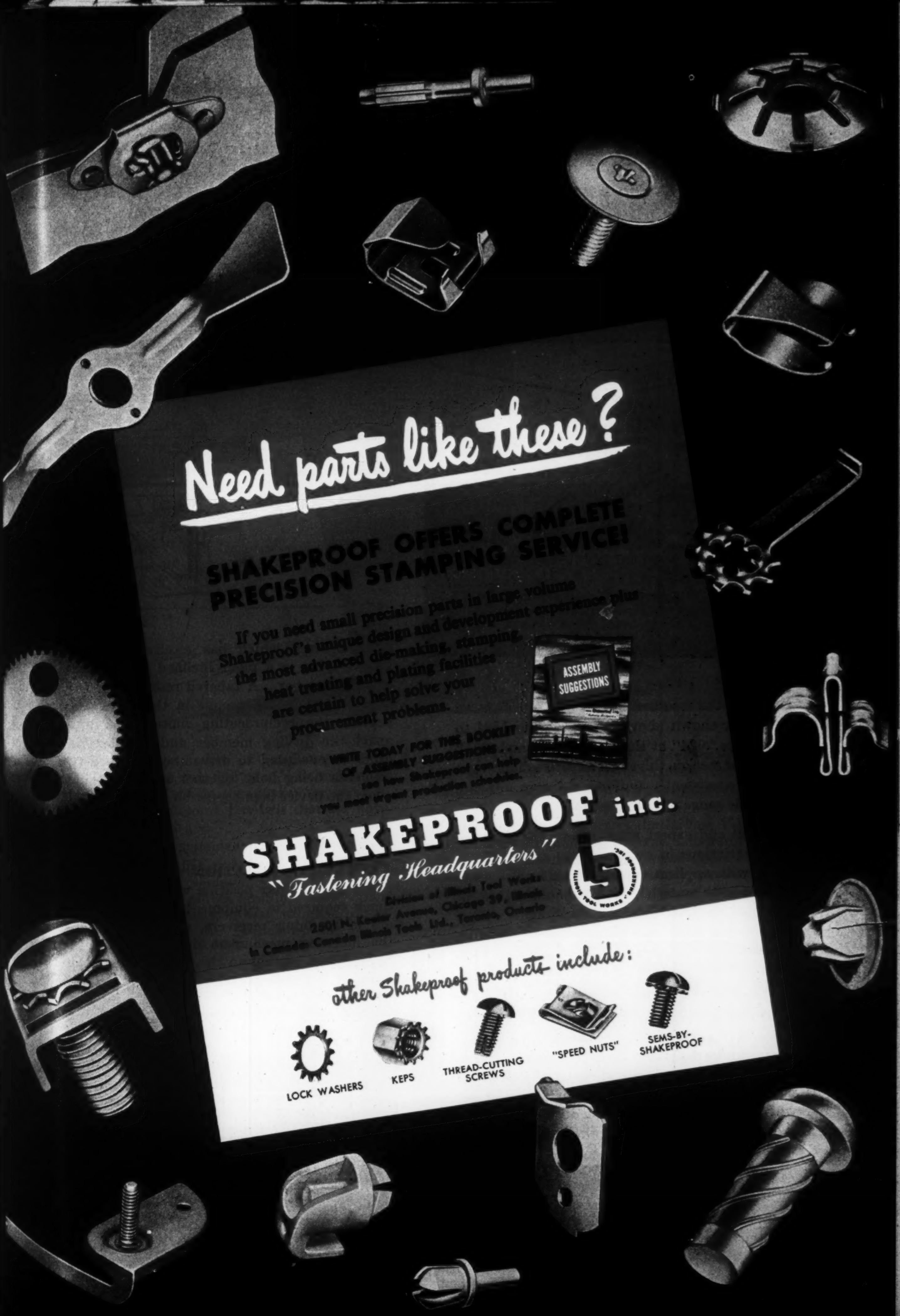
WRITE FOR FREE MANUAL illustrating and describing conveyor belt installations for food, metalworking, chemical, ceramic and other processes.



internal roller on the inside of the ring. This deforms the ring, thus increasing the rolling friction and, consequently, the tension on the wire. As wire tension increases, rolling friction between ring and roller are decreased and drag on the wire is lessened. The mechanism, assigned to the General Electric Co. by William R. Hunt, minimizes cold working by passing the wire around a single wheel only.

ROTARY SOLENOID ACTION is obtainable by employing a simple link mechanism to convert axial movement of a solenoid armature into an intermittent rotary movement. An armature is mounted to rotate on its shaft and carries the lower ends of several ball-and-rod link members, with the upper ends of the links held in a stationary plate. A coil spring tends to rotate the armature in a counterclockwise direction, which tilts the links with respect to the shaft axis. Energizing the solenoid coil moves the armature downward and increases the axial distance between the two pivot points or ends of the links. The links therefore tend to straighten out, applying a torque to the armature assembly which rotates it in





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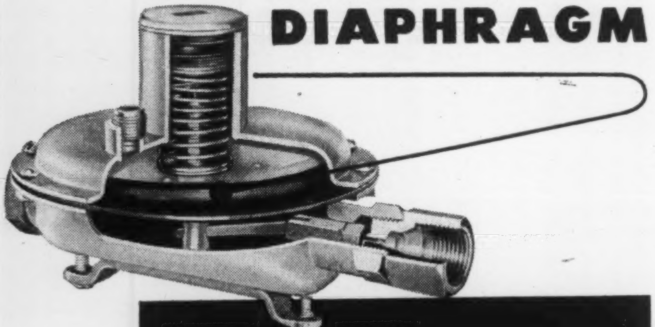

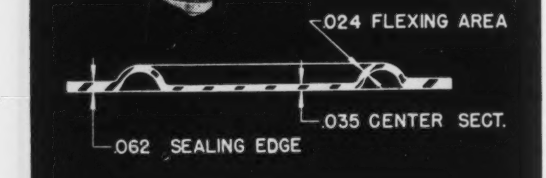

Cross-sectional view of supersensitive synthetic rubber diaphragm.

TYPICAL is the result obtained with the LINEAR Diaphragm, shown above. Precision moulded to a .062″ edge, .024″ at the flexing area, and .035″ in the center section, this super sensitive diaphragm assures a consistently uniform delivery pressure over a wide range of inlet pressures.

Detailed and expert attention to the need for minute variations in cross-sections and radii . . . coupled with application experience in the selection of specific materials . . . has enabled LINEAR to produce precision-moulded diaphragms with a rolling action that eliminates stresses, reduces hysteresis and increases life. Thus, LINEAR Diaphragms offer advantages that cannot be achieved with flat diaphragms . . . frequently at lower cost.

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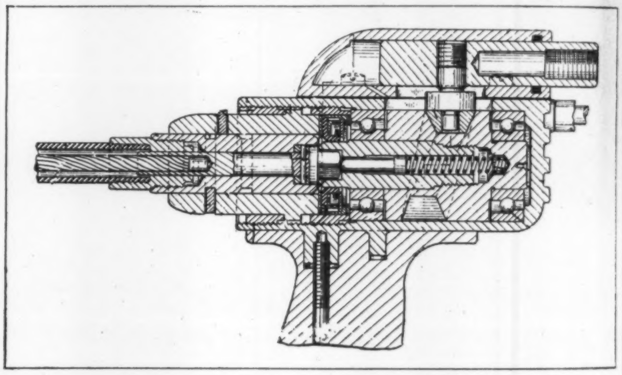
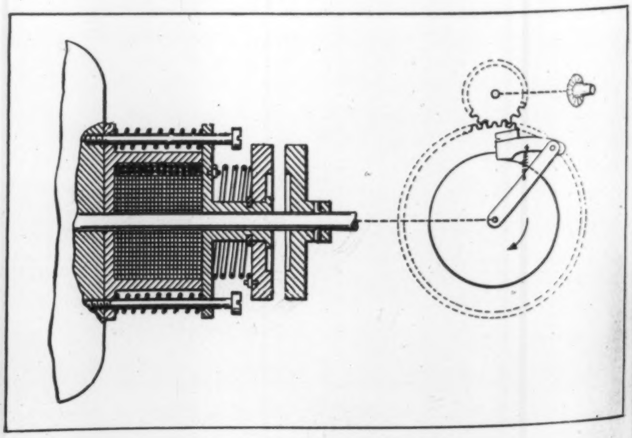
a clockwise direction against the spring force. Rotary motion of the armature can be made to actuate a timer, for instance, by means of a suitable pawl and ratchet arrangement. The patent, No. 2,531,905, has been granted to Glenn W. Carpenter and assigned to P. R. Mallory & Co. Inc.

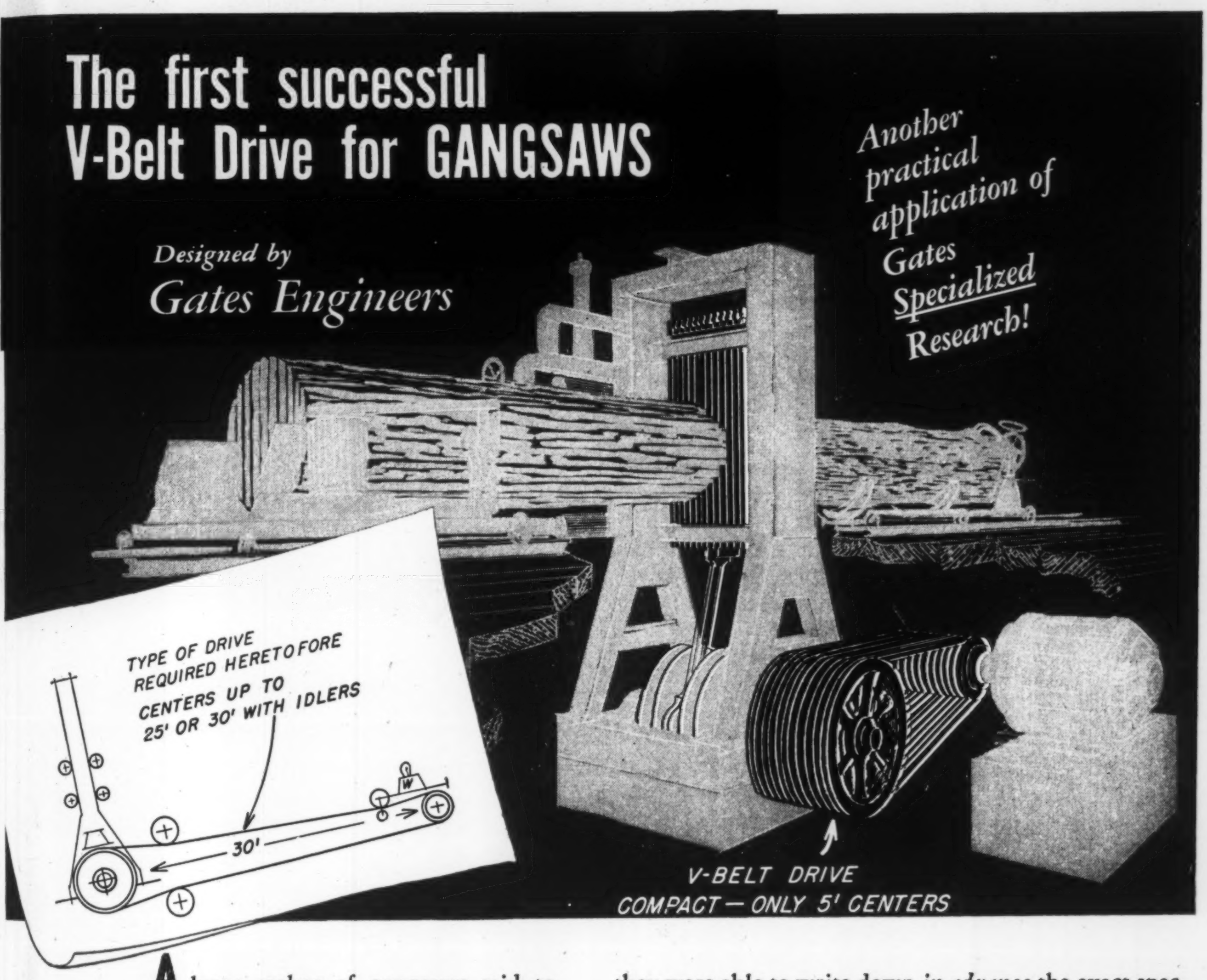
TRANSLATION of rotary to reciprocating motion in hand power tools is simply accomplished as covered in patent 2,525,922, assigned to Blackhawk Manufacturing Co. by Siegmund Mandl. Rotary motion is imparted to a circular driving member, mounted in ball bearings, which has a circumferential tapered groove lying in a plane inclined from the axis of the driving member. A tapered roller carried by the tool holder runs in the groove in the driving member to provide the reciprocating motion. A spring holds apart the driving member and the flexible shaft or other means used to drive the tool, the two driving elements being held together against spring pressure when the device is in operation.



ACCURATE LOCATION of a rotating shaft in a particular angular position when stopped, as is sometimes required in equipment such as tuning condensers in scanning receivers, can be accomplished with the indexing mechanism described in patent 2,528,489. When current to the drive motor is interrupted, an electromagnet-operated clutch attached to the ro-



The first successful V-Belt Drive for GANGSAWS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Gates Engineers
Another practical application of Gates Specialized Research!
TYPE OF DRIVE REQUIRED HERETOFORE
CENTERS UP TO 25' OR 30' WITH IDLERS
W
30'
V-BELT DRIVE
COMPACT—ONLY 5' CENTERS

A large maker of gangsaws said to Gates Engineers, "If you can design a V-Belt drive to handle the *fluctuating load* on a gangsaw, we can discard the long and troublesome flat belt that we have always thought we had to use."

The *reasons* for his statement are quickly told:—

A gangsaw (or Swedish type Gang Mill) consists essentially of several saw blades mounted in a heavy steel frame or "sash" that moves rapidly up and down like a monster jig saw. This sash may weigh a ton or more—yet it makes about *five* 24-inch *up* and *down strokes per second!*

On the *up* strokes, the saws have no cutting load on them. But on the *down* strokes they must often slash a log up to 36" diameter into 2" planks. This great unbalance in load between the *up* and the *down* strokes has heretofore defeated all efforts to apply a V-Belt Drive to saws of this type.

After thoroughly analysing the fluctuating load on gangsaws, Gates Engineers recommended very minor changes in design which would permit the application of V-Belts and—what is of *utmost importance to you*—they were able to write down *in advance* the exact specifications of the V-Belt Drive that has very successfully handled this extremely difficult assignment.

This *pre-solution* of drive design problems is possible because Gates operates the largest V-Belt testing Laboratories in the World—and Laboratory findings are carefully checked by tests made under actual field conditions. Finally, the *results* of these exhaustive tests are immediately reduced to *usable data* for the design of V-Belt drives to *perform whatever task may be required.*

Phone a Gates Field Engineer

If you have a difficult drive to design, or if some drive in your plant is giving trouble, or if you only want to be sure what size and construction of V-Belts will give the most efficient and the lowest cost service on any particular drive—you have only to phone a Gates Field Engineer, *always near you* in all industrial centers.

Just look in your phone book under "Gates Rubber." A Gates Field Engineer will come right to your plant and put at your service the full benefits of Gates V-Belt knowledge and experience *without the slightest obligation!*

ENG. 515

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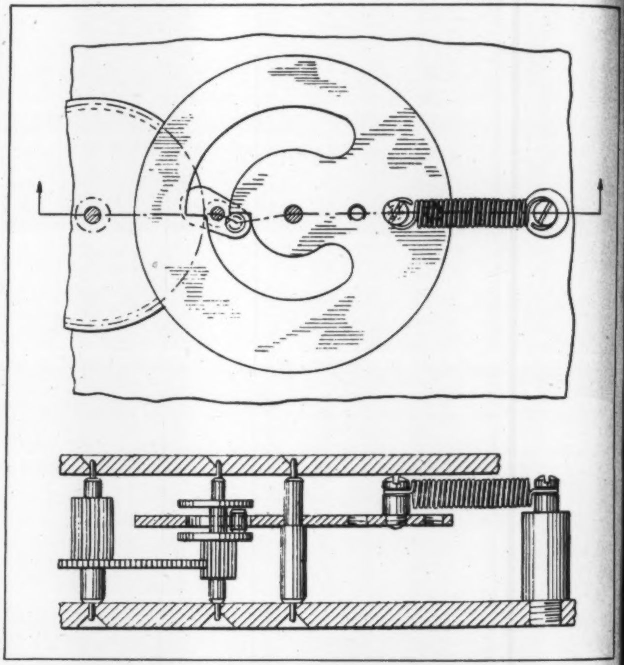
tating shaft is released. Inertia of the motor armature and shaft then winds up a helical or coil spring attached to the second clutch half. Tension in the wound spring stops the shaft, then reverses it until a pawl linked to the shaft has backed up to a stop on the cam. The angular position of this cam can be adjusted by rotating the gear on which the cam is mounted. When the motor shaft is rotating in the forward direction at full speed, the pawl is held away from the cam face by centrifugal force. During the slow-speed reverse rotation, however, a spring holds the pawl against the cam face. Casper S. Bednash and Gordon S. Burroughs have assigned the patent to Federal Telephone and Radio Corp.

SIMPLIFIED ESCAPEMENTS, designed to replace more costly and delicate air-braked flywheels, centrifugal brakes, etc. in slow-acting timing relays, eliminate variations in speed of the gear train because of changes in applied torque. A roller attached to the input pinion imparts an impulse to a pivoted disk or balance through one of two shoulders in a slot in the balance. When the balance is in a displaced position, further rotation of the roller, and therefore the gear train, is prevented by a locking surface on the edge of the slot which contacts and holds the roller. As the balance returns to its center position, the roller is released and gives an impulse to the balance wheel in the other direction. The input wheel, on which a continual torque is applied, can rotate only when the roller and pinion are unlocked. By changing tension in the coil spring which centers the balance, the period of oscillation of the balance can be adjusted. Using a spiral or hairspring fastened to the balance at its center permits larger periods and greater precision. The patent, No. 2,526,620, has been granted to Henri Jeanneret, La Chaux-de-Fonds, Switzerland.



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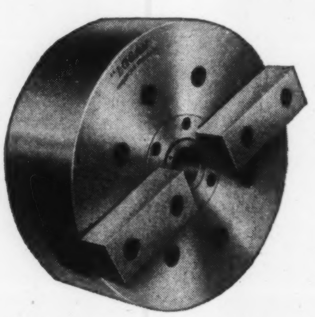
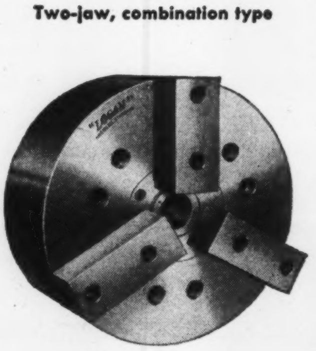


Two-jaw, combination type



Three-jaw, universal type

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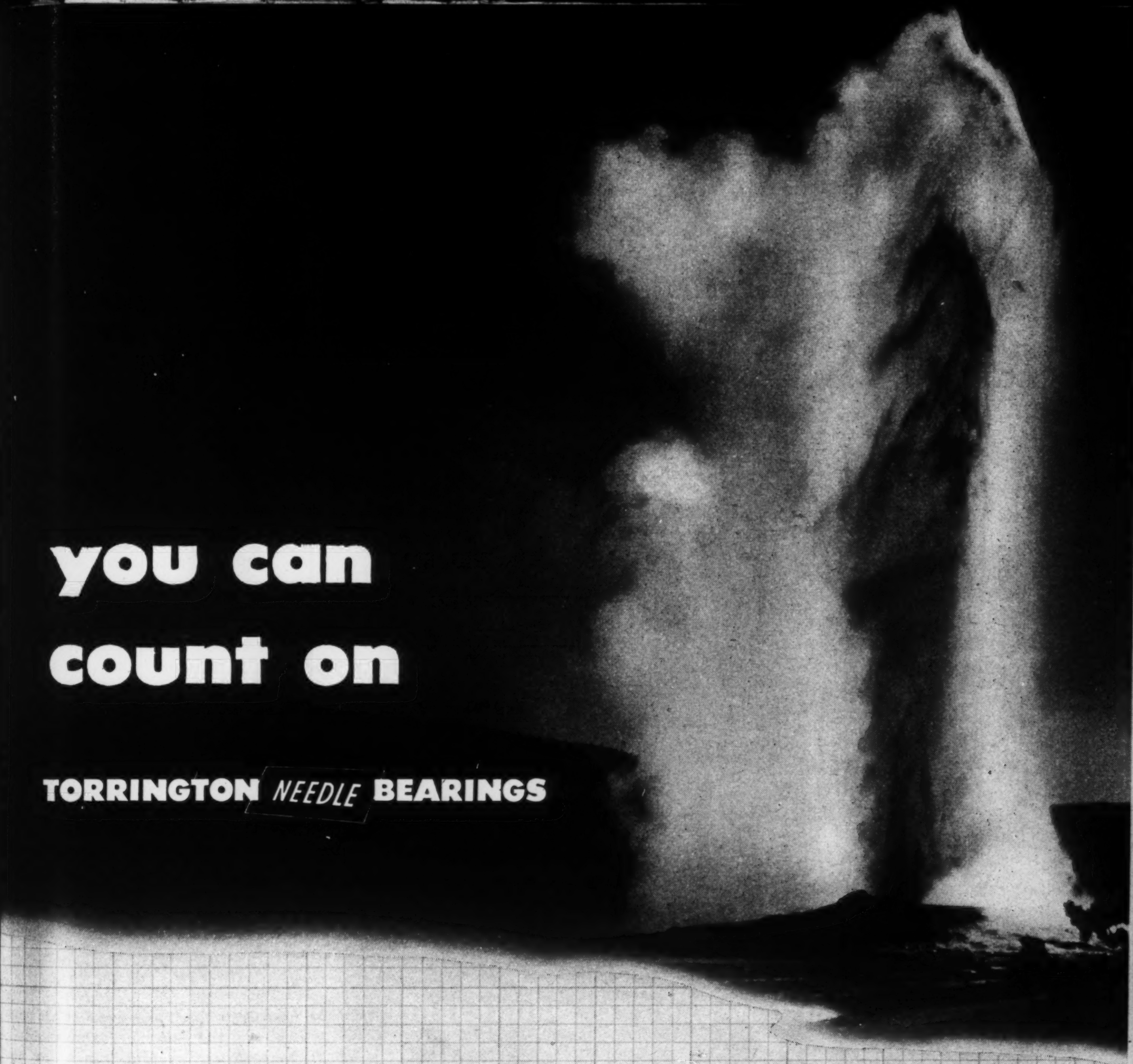

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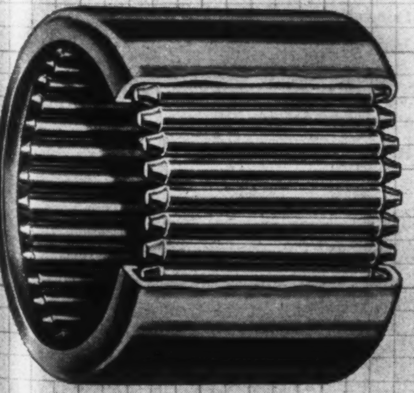

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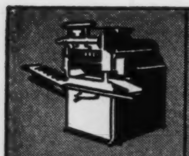
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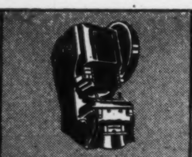
Baker Perkins
"Dough Divider"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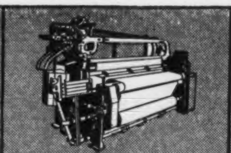
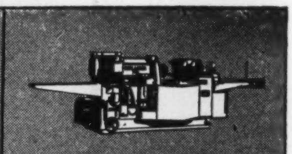
Bliss
"Inclinable Press"


TEXTILE
Crompton & Knowles
"Loom"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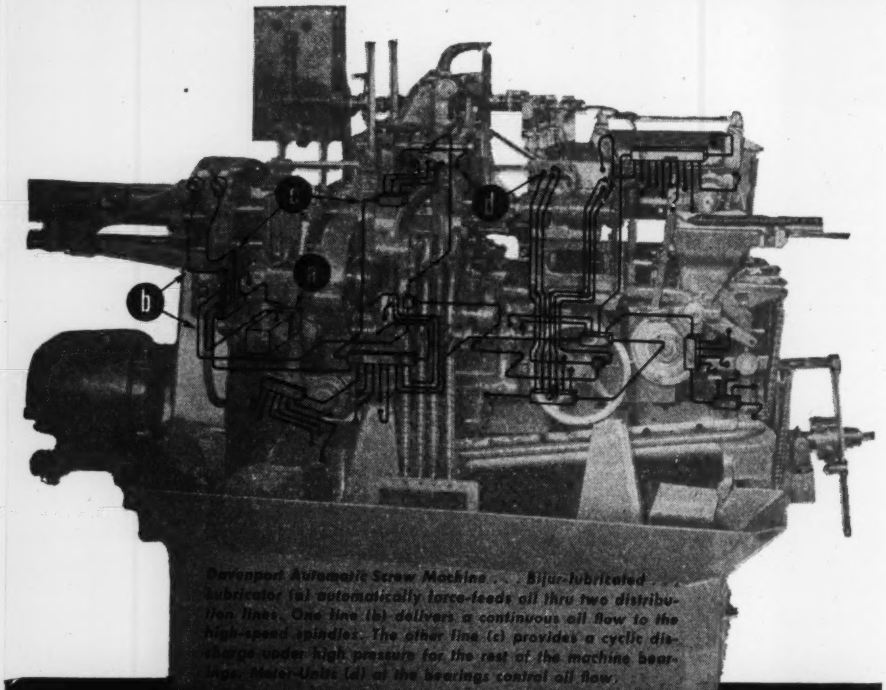
automatic lubrication



Davenport Automatic Screw Machine . . . Bijur-lubricated . . . Lubricator (a) automatically force-feeds oil thru two distribution lines. One line (b) delivers a continuous oil flow to the high-speed spindles. The other line (c) provides a cyclic discharge under high pressure for the rest of the machine bearings. Meter-Units (d) at the bearings control oil flow.

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to each
individual
bearing...

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LUBRICATING CORPORATION

LONG ISLAND CITY 1, NEW YORK

Design Abstracts

(*Continued from Page* 167)

on this latter premise that the wing cells were arranged.

The next decision was probably the most difficult one—integral tanks versus bladder cells. Numerous airplanes were in service with integral tanks and fuel leaks were too serious to pass over lightly. Lockheed had accumulated perhaps more experience with this type of tank than any other airframe manufacturer and was fully aware of the seriousness of the situation. Despite this, it was felt that a satisfactory integral tank could be developed in order to retain the weight advantage. Instead of sealing off a normal section of wing, the tank area was established and the wing structure was designed to fit the tank instead of vice versa.

One of the more interesting structural problems solved in the development of the *Constitution* was the technique by which structural continuity was maintained in the wing without jeopardizing the ability of the integral gas tanks to contain the aircraft fuel. The basic decision was made that all surface structure would be broken at the tank walls and contained again inside the tank so that no difficult sealing problem would be encountered due to piercing of the tank ribs by peculiar structural shapes.

Supercharger Air Pressure System

Air Systems: The source of air pressure is the engine exhaust-driven supercharger system. Since the airplane is designed to operate at a cruising altitude of 25,000 feet, each engine is equipped with a turbo supercharger. Thus, there exists a natural source of pressure air without mechanically driven supercharging. Based on previous experience obtained on the *Constellation*, an assumed rate of fuselage leakage, to be expected in service, was 30 pounds of air per minute. To assure sufficient safety margin, it was decided that each power source should contribute 30 pounds of air per minute or a total of 120.

In order to control pressure, as well as rate of ascent and descent within the fuselage, a completely automatic outflow valve is installed immediately behind the flight engineer. This valve is a large bell-mouth plug type which is motor actuated and was designed and built for the specific job by Minneapolis-Honeywell. To further protect the airplane there is installed at the tail cone a pair of large pres-

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sure relief valves which are spring-loaded and operate at excessive pressure without any external power requirements.

To assure adequate distribution of the cabin air throughout the occupied zones, as well as to conserve the air supply, a recirculating system is used.

The prime source for heating cabin, wing and tail surfaces is the engine exhaust system. A large heat exchanger is installed in each of the engine exhaust tail pipes so that all of the exhaust, under all operating conditions except take-off, passes through the exchanger.

Four Isolated Cabin Zones

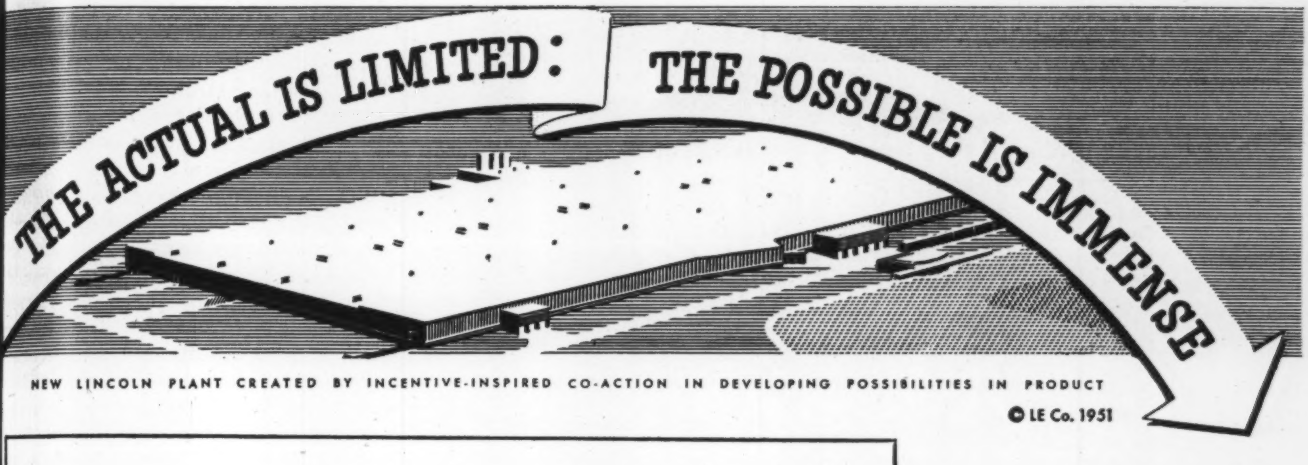
The cabin is divided into four basic zones, each isolated from the other. This, in terms of heating, means that the heat requirement in each zone can differ widely from any other, depending not only on volume but on the type of load carried in each.

The manner in which the heated air is distributed to wing and tail surfaces follows generally conventional practice as it is known today. Initial tests of the thermal deicing under dry air conditions indicated that the anti-icing air temperature exceeded the limit of 300 F. There was a further restriction imposed to limit the temperature in areas that contained unaged 24S-T to 200 F to prevent corrosion and reduction of strength. All areas in vertical and horizontal stabilizers were affected by this limitation. Temperatures in all areas were reduced to an acceptable value by increasing the air flow through the primary heat exchanger by providing a cold air passage through the center of this heat exchanger.

Landing Gear: In the early stages of the design, various landing gear types were studied, including single and dual-wheel gears, track-type gears, and the four-wheel type finally chosen. Subsequent development of this landing gear, which was selected because it appeared to take up minimum space in the wing and appeared to have the maximum load carrying capacity for a minimum weight, amply justified the original conclusion.

Trombone Strut Landing Gear

Of interest in the basic gear design is the fact that the two landing gears were tied together by a sliding trombone type of strut, as shown on *Fig.* 6, which keeps the geare aligned one with the other and replaced the normal scissors type of alignment mechanism which is structurally inefficient and, as a result, extremely heavy. The trombone principle was also utilized in carrying the brake pressure line from the major structure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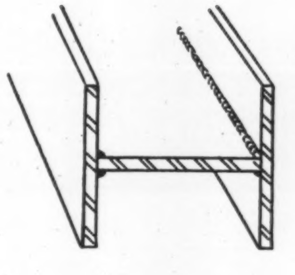

Fig. 3. "I" section. Higher strength to weight ratio under lower loading conditions is gained through better distribution of metal in outer areas. Needs 85% less metal than Figure 1 . . . 40% less metal than Figure 2.

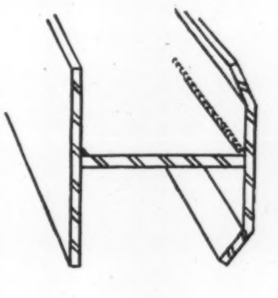

Fig. 4. Bottom flange of "I" section can be brake formed from light material and Automatic Lincolnwelded on one side only to web. Saves 10% metal and 50% fabricating cost over section shown in Figure 3.

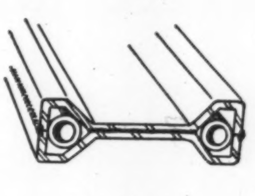

Fig. 5. Pressed steel section formed from light gauge metal. Die formed half sections are assembled over steel tubing and Automatic Lincolnwelded at outer edges. Weighs 80% less than Figure 1.

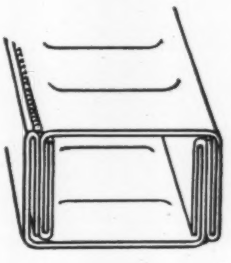

Fig. 6. Box section is fabricated from lighter gauge sheet than Figure 5. Flanges are folded metal to increase amount of material at outer edges. Web is corrugated to achieve maximum strength per pound. Weighs 5% less than Figure 5. Is Automatic Lincolnwelded for lowest fabrication cost.

the ACTUAL

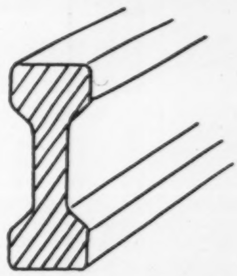

Fig. 1. Cross section through an iron cantilever beam designed to resist a bending moment.

increasing the YIELD

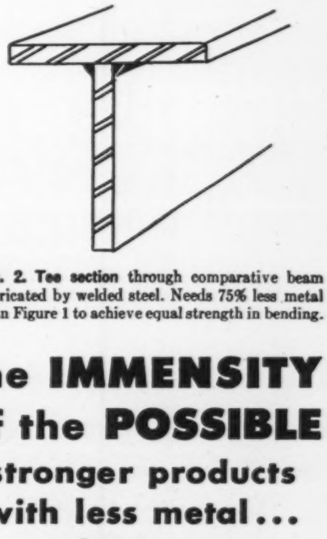

Fig. 2. Tee section through comparative beam fabricated by welded steel. Needs 75% less metal than Figure 1 to achieve equal strength in bending.

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down to the wheels, replacing the usual flexible line which would have been extremely large on this gear due to the long stroke.

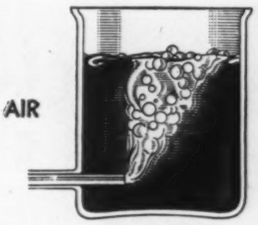
The rigidity of the structure and the simulated air loads on the landing gear apparently were not the same as in flight because deformation of the structure resulted in binding of the down locks. This was corrected by providing more clearance. Main landing gear wheel prerotation has an effect on structural design since it substantially reduces the drag load on the gear. Each engine-driven 120-v generator drives the prerotation motors for a pair of wheels. The motors turn the wheels to an equivalent speed of 80 mph +10 per cent. Upon contact with the ground, the prerotation motors are shut off by the main landing gear scissors switch. Aside from the reduction in structural loads, there are other benefits to be realized from the prerotation installation—structural life, tire life and passenger comfort.

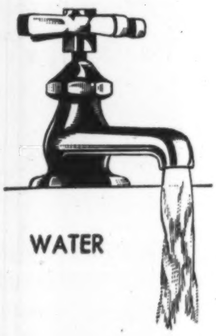
Unique Wing Flap Mechanism

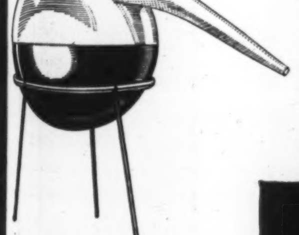
WING FLAP SYSTEM: Another major mechanical development program involved the design of the wing flap system and the tracks. Since it was desirable to carry the wing rear beam aft as far as possible on the wing to clear the landing gear cutout and increase the wing tank capacity, the problem of obtaining large chord flaps of the Fowler type was substantially increased. A system was finally evolved, however, which proved to be one of the most satisfactory ever developed at Lockheed. The principle is basically that of the filing cabinet drawer mechanism in which a subtrack travels on a basic rail and the flap itself travels on the subtrack. *Fig.* 7 illustrates the wing flap mechanism.

A combination system was evolved which retained the weight advantages of the cable drive and avoided the difficulties of rigging by interconnecting a simple cable system at each track with a torque tube which actually drove each track system from the basic drive in the fuselage. Thus, each cable system was short and any rigging of any truck cable had no effect whatsoever on the rigging of the other track cables. This permitted simple adjustments and, since each cable system was short, no "out of rig" problems have occurred due to the deflection of pulley brackets, etc., which plague a normal long distance cable system.

From a paper entitled "The Lockheed Constitution Development Story," presented at the SAE Annual Meeting in Detroit, January 8-12, 1951. *Complete copies may be obtained*







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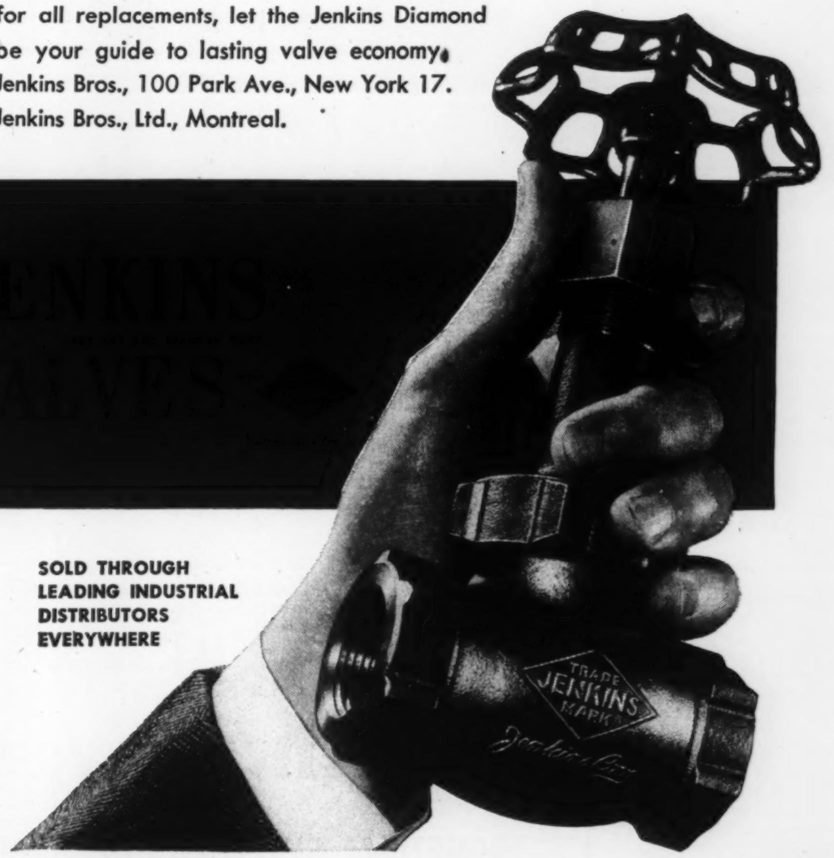
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MEMO TO SALES-MINDED DESIGN ENGINEERS:

ARE YOU designing equipment in which fluid control is a function of operation? Jenkins' reputation for top quality valves with longer service life can give your product added sales appeal. In buyers' eyes, the name JENKINS makes any valve-equipped product a better product.

FAWICK CLUTCHES INSURE POSITIVE REMOTE CONTROL ON MINE HOIST INSTALLATION

Electric Man and Material Hoist at the Pana, Illinois mine of the Peabody Coal Co. This hoist, manufactured by Robert Holmes and Bros. Inc. utilizes two Fawick 28CB525 Dual Clutches on both the man and material drives. A Fawick 21.5E475 Unit is used on the motor shaft as an auxiliary brake.

Fawick Airflex Clutches play a very important part in the operation of this heavy-duty mine hoist, where the repeated starting and stopping throw heavy loads on the entire drive mechanism.

The two Fawick Dual Clutches installed on the low and high speed drives provide vital operating characteristics. They give instant response to remote control from the "hoistman's" station, permitting "shifting" of hoist speeds.

The cushioning action of the flexible Fawick Clutch operating tubes reduces load shocks to the gearing.

These same operating characteristics plus the rugged design and simplicity of Fawick Clutches and Brakes contribute greatly to long, top-efficiency operation in industrial applications. On this, as on many other installations, Fawick Clutches make good machines better.

FAWICK AIRFLEX CO., INC.
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For specific information on all advantages of Fawick Clutch and Brake units, write to the Main Office, Cleveland, Ohio, for Bulletin 300.

FAWICK Airflex
INDUSTRIAL CLUTCHES AND BRAKES

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Personal Progress in Machine Design

By J. F. Downie Smith
Iowa State College
Ames, Iowa

WHAT would the young graduate have to do to prepare himself for promotion in the field of machine design? Probably, at the very beginning, he would be put on a board and would work as a detailer, taking the designs prepared by a competent designer and preparing the details for production. This is a very necessary training for a designer. No man should really classify himself as a designer who doesn't know how to make the individual parts in the shop. Also, in conjunction with this detailing experience, the student should take a course in the shop, in order to acquire at least a superficial knowledge of how the various machines operate and how parts are made. This gives him a clearer picture when he starts to make details, and, if undecided how to make a particular part, his machine-shop training would stand him in good stead.

After getting this machine-shop and detailing experience, it would be expected, if he shows promise, that he would be put on layout work and then on the designing of small parts, and eventually on more complicated machines. Before a man can become a designer he should not only have the ability to create new designs but also have the capacity to think in three dimensions. If there are moving parts in a compact machine, the designer must be able to visualize in his mind how these parts are going to behave relative to one another, and whether, for example, there might be interferences. It is much cheaper to eliminate interferences on the drawing board than in metal.

Engineering is not a static profession. New materials and new designs are being developed constantly. Thus it would be expected that a young graduate should try to keep up with the world after he has graduated and not assume that he has acquired all his education. For example, in the design of parts of a machine, a new development might indicate that a certain plastic material would be better suited than

This *different* Air Cylinder Simplifies Designing *for pneumatic operation*

● The Bellows Air Motor is a complete air cylinder power unit, with directional valve and speed controls built-in. It requires only one air connection which can be made with flexible hose ● The electrically-controlled Bellows Air Motor takes less than half the space required for a conventional air cylinder set-up of equal power. Compact and complete, it fits well into cramped quarters or on moving machine elements ● The built-in ELECTROAIRE VALVE* is solenoid-controlled, but air-powered. It's bullet fast, speeds up to 2200 movements per minute. But there's no pounding, no overheating. In fact, the solenoid control units are guaranteed against burnout. The low voltage used to operate the solenoid controls (8 volts) makes this unique air cylinder electrically safe for operators and machines. The low voltage simplifies wiring, permitting safe, positive interlocked electrical circuits with a minimum of design difficulties. ● Design with air in mind. With electrically controlled Bellows Air Motors you can eliminate cams, levers, gears, linkages or other mechanical means for performing push, pull or lift motions . . . saving designing time and production costs.

This new 30-page booklet tells the complete story.

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Ask for Bulletin CL-30.
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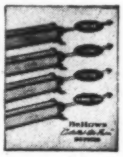
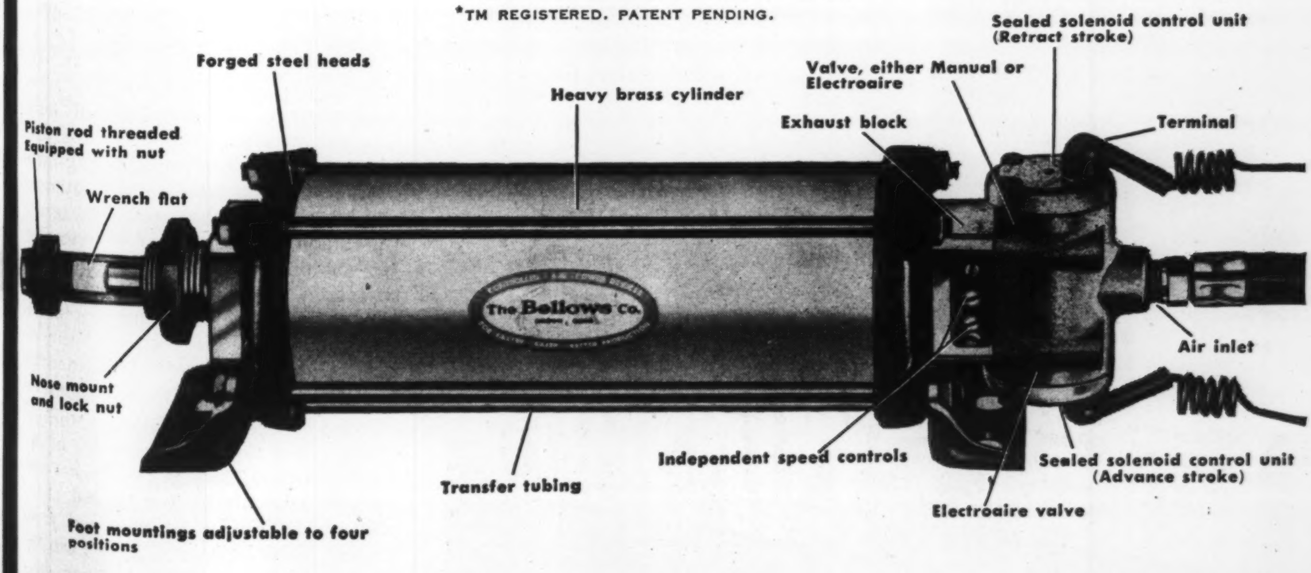


The Bellows Co.

AKRON 9, OHIO

The Bellows Air Motor illustrated is Model BEM5-25 (2½" bore, 2½" stroke). Other bore sizes are 1¼", 1¾", 2½", 3⅜" and 4½". Any stroke length. Model shown is equipped with the ELECTROAIRE VALVE for full electrical control. Air motors with manually operated valves are also available.

*TM REGISTERED. PATENT PENDING.


Sealed solenoid control unit (Retract stroke)
Forged steel heads
Valve, either Manual or Electroaire
Heavy brass cylinder
Piston rod threaded Equipped with nut
Exhaust block
Terminal
Wrench flat
The Bellows Co.
Air inlet
Nose mount and lock nut
Independent speed controls
Sealed solenoid control unit (Advance stroke)
Transfer tubing
Electroaire valve
Foot mountings adjustable to four positions

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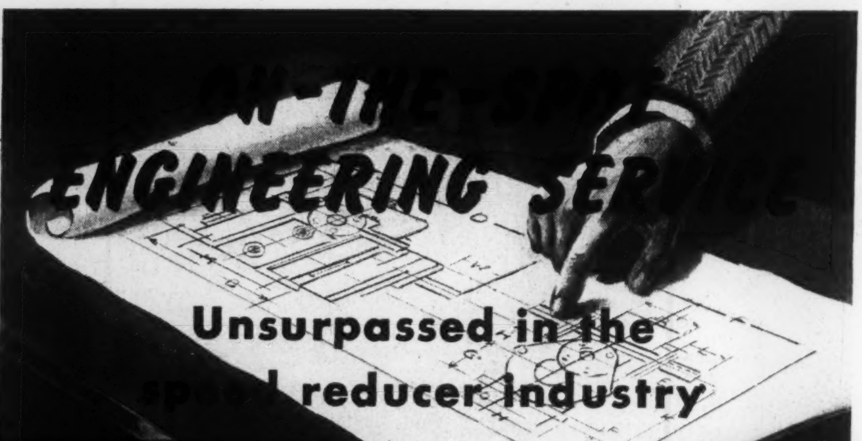
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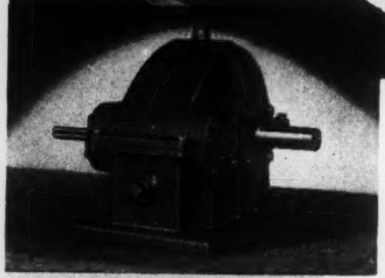
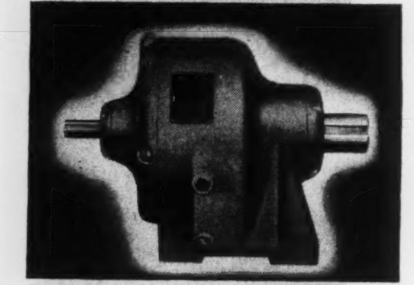
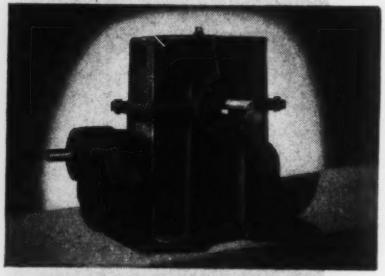


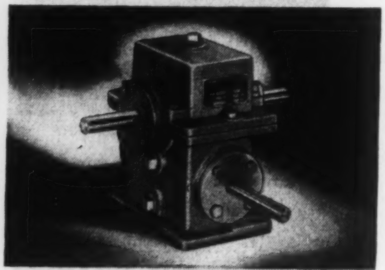
Helical Gear



Pat. Differential Gear



Worm-Helical Gear



Worm Gear

The fact that Winsmith has today the most complete, fully standardized line of speed reducers (from fractional to 85 hp), never for a moment diminishes the highly personalized, power transmission engineering service which it has always stressed.

For regardless if it appears that your needs can be amply served by a standard design and size, Winsmith still encourages consultation with your design engineers or consultants. It can save you considerable time and costs in engineering and installation.

So, whether your equipment is an automatic pin spotter or an automatic washing machine, a can filler or a compressor, a printing press or a pump . . . consult early with Winsmith's factory trained nationwide representatives, while your product is still in the design stage, if possible. Naturally, no obligation is involved.

Names and addresses of Winsmith engineering representatives in your locality, gladly furnished.

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WINSMITH
SPEED REDUCERS

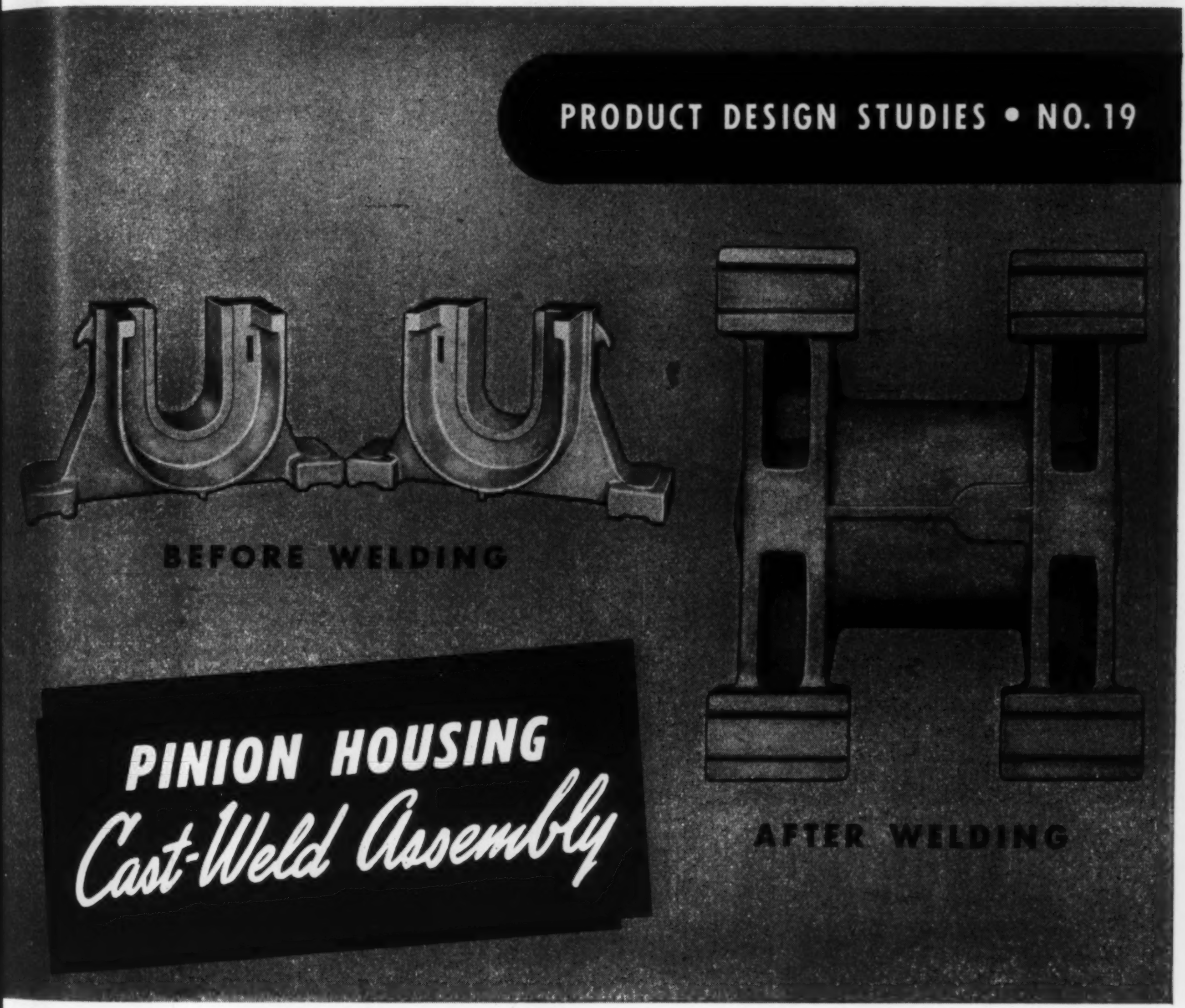
steel. Unless the young man was aware that the new plastic existed, he would be in no position to determine whether it should be used. Perhaps the easiest way for the young engineer to keep abreast of new developments is to maintain an active membership in a technical society. The mechanical engineer, for example, could maintain membership in the American Society of Mechanical Engineers and should read the technical articles which might be of use to him in his daily work. This, of course, is not enough. Many things are developed which are not published. Sometimes a man can get considerable help by talking things over with other workers in the same general field. This, generally, means that the man has to acquire acquaintanceship with several engineers, at least, in his neighborhood.

In order to take part in activities either of the national or local branches of the Society, the graduate should not become merely a listener. He should participate. This means that he should acquire the ability to write and to speak effectively. Unfortunately, in the past, engineers have paid too little attention to the ability to speak in public, and this has been reflected in salary scales. For many years, however, it has been apparent that engineers have been paying more attention to it, and this has shown up in the promotions made by men in the engineering field.

Promotions to Executive Increasing

The percentage of engineers who have come up through the ranks of designing to reach positions of prominence is increasing steadily. The only trouble is that there are so few such men that generally a choice cannot be made, and thus the opportunities for the young men with college training, creative ability, and some shop experience are very great. Any executive today should know something about business, too, and thus if a designer is expecting to be promoted eventually to a position of responsibility, he should not ignore the business aspects of engineering. He should know, for example, how to read a balance sheet, how to prepare a budget, how to prepare intelligible reports to be read by businessmen, and how to defend engineering practices in talks with nonengineers.

From a paper entitled "Machine Design as a Career," presented at the ASME Annual Meeting in New York, November 26-December 1, 1950. Complete copies may be obtained from ASME, 29 W. 39th St., New York 18; $0.25 each to members, $0.50 to nonmembers.



15% Saving Accomplished By Using Cast-Weld Construction

Eight of these 3-ton rolling mill pinion housings were required. The design being different from housings frequently produced as single steel castings posed the need for new pattern equipment.

By producing the housing as two steel castings and welding them together to form the desired shape, only a half pattern was required and the need for a main body core was eliminated. Result — a 15% saving in over-all cost.

* * *

Conversion of some of your parts to *foundry engineered* cast-weld assemblies and *foundry engineered* steel castings — through close cooperation of your engineering department and the steel foundry — may result in more production, of better quality, in less time and with less metal.

Your steel foundry representative will welcome an opportunity to make available to you his company's long experience *plus* the full results of the development and research program carried on by the Steel Founders' Society of America.

An Urgent Message About Scrap . . .

There is a serious shortage of iron and steel scrap. Your company can help insure the continued high production of all metal products by getting your scrap into the hands of your scrap dealer. Will you do what you can to help . . . now?

STEEL FOUNDERS' SOCIETY OF AMERICA
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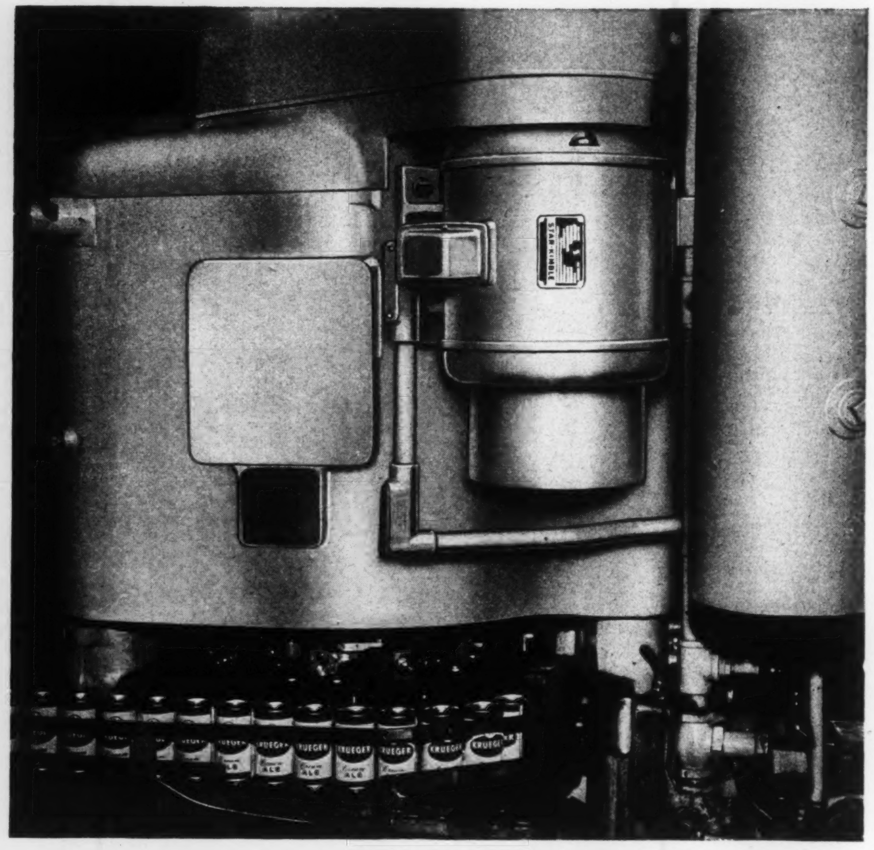
Design and Build With Steel Castings



FROM FULL SPEED TO STANDSTILL IN 1/5 SECOND

...with Star-Kimble Brakemotors on American Can Closers

THERE'S scarcely a chance that a can will jam on a closing machine built by American Can Company—but American *takes every precaution to avoid jamming damage.*

In the machine shown, which seals 300 cans a minute at the Newark plant of the G. Krueger Brewing Company, power is automatically cut off if jamming occurs. Then a Star-Kimble Brakemotor brings the machine to a stop within a single can cycle—that means *within one-fifth of a second!*

Whether split-second stops like this are needed only in an occasional emergency . . . or whether the service calls for *repeated* start-stop cycles at short intervals . . . you can count on the *extra-large* disc area of a Star-Kimble Brakemotor to provide *extra-fast* braking and positive holding. *Starts* are fast and smooth, too—free from friction drag. Small magnetic air gap assures speedy brake release.

In thousands of applications, under the toughest conditions, Star-Kimble Brakemotors have proved their ability to run for years with little or no attention. *Remember* . . . with its motor and brake *built* together to *work* together, each Brakemotor is an integral, space-saving unit *designed* for its specific job by the pioneer makers of disc brakemotors, and *backed* by more than 25 years of application experience.

For full information on construction and ratings, write for free Bulletin B-501-A.

STAR-KIMBLE

MOTOR DIVISION OF
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News

OF MANUFACTURERS

Reynolds Metals Co. has taken over the management of the United States Air Force's Manufacturing Methods pilot plant at Adrian, Mich. The $20,000,000 government-owned and industry operated facility will be used for developing forgings and extrusion techniques and the proving of theoretical designs. No actual production will take place in the plant under the contract with Reynolds, except in the case of emergency. The plant is to be operated by Reynolds without fee or profit.

◆

Bronze Bearings Inc., Cranford, N. J., has been organized to take over the manufacture and sale of bronze bearings, bushings, graphited oil-less bearings, and nonferrous castings formerly produced by S & H Bearing Mfg. Co. Several installations of new equipment have been added to the machine shop, as well as to the foundry; new handling equipment has also been installed.

◆

J. J. Tourek Mfg. Co., manufacturer of precision screw machine products, ball joints and pipe plugs, has started construction on a new plant at 1901 S. Kilbourn Ave., Chicago Ill. The new one-story structure will have an area of 60,000 sq ft, twice the space of the company's present quarters.

◆

Hanna Engineering Works, Chicago, Ill., manufacturer of hydraulic and pneumatic cylinders, valves and riveters, is celebrating its fiftieth anniversary this year.

◆

General Electric Co.'s Aircraft Ga Turbine Divisions, Cincinnati, O., will further development of a nuclear reactor for aircraft. The Atomic Energy Commission has authorized negotiation of a contract for the development.

◆

Westinghouse Electric Corp. has announced that its J40 turbojet engine has completed qualification test and is now going into substanti production. According to Westinghouse's Aviation Gas Turbine Division, South Philadelphia, Pa., production of the engines will provid

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where we discuss problems that deal with tubing and its various functions.

There's no point in your struggling with a tubing problem
when you can have the answer so readily here in Customer Engineering Service.

The vast experience of more than three decades of
extensive tube-making is represented within this department.
And it's all available for you to draw on without cost.

Just because tube is immobile when installed, don't dismiss it
as something that needs no more consideration than that. In its diverse forms
it can serve you efficiently or inefficiently.

The time to think about the specifications of your tube requirements is *before*
you make your installations—before you encounter difficulties—
so you can be sure that the product you are building—that
may require plain or fabricated tube—will function in the highest degree of efficiency.

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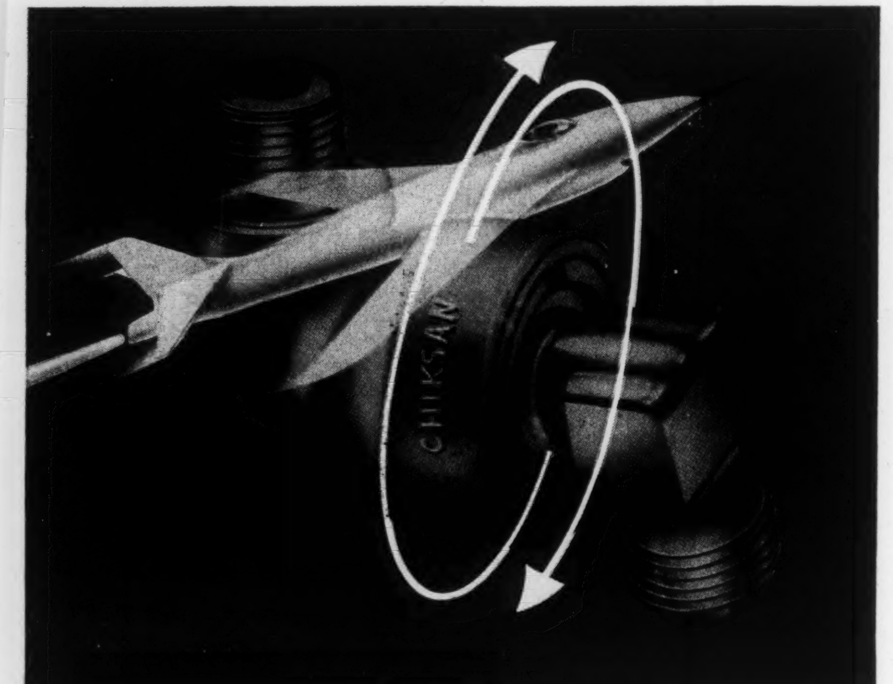

CHIKSAN

STANDARD APPLICATIONS FOR
CHIKSAN AIRCRAFT SWIVEL JOINTS
FUEL DUMP CHUTES • WING FOLD •
FLIGHT CONTROL • OXYGEN LINES
• HYDRAULIC LINES, LANDING GEAR
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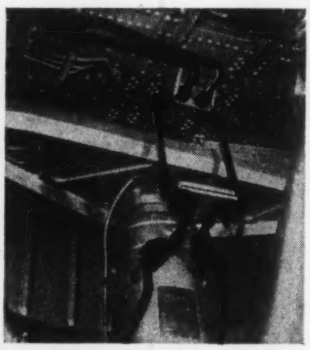
No need to waste precious time...and money...on design, mock-up and testing to develop Swivel Joints for your flexible lines. CHIKSAN *Ball-Bearing* Swivel Joints are proved *now* for all kinds of applications.

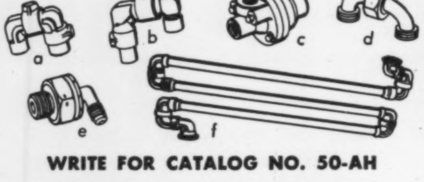
With CHIKSAN Swivel Joints, you can build flexible lines with all-metal tubing which permit tight bends and fit into limited space...lines which permit unlimited flexibility without drag or sag...lines which assure maximum safety and dependability under pressures to 3,000 psi. (to 15,000 psi. on industrial applications).

CHIKSAN performance is proved by the continued acceptance of leading Aircraft and Industrial manufacturers for applications in civilian and military equipment for use on land, on the sea and in the air.

(a) Basic Type Swivel Joints—for pressures from 125 psi. to 15,000 psi. (b) High Temperature Swivel Joints for temperatures to 500° F., working pressures to 700 psi. (c) Rotating Joints for 150-lb. steam, brine, etc. For hot and cold rolls, tumblers, platens, etc. (d) Sanitary Swivel Joints for food processing, fruit juices, dairies, etc. (e) Hydraulic Swivel Joints for pressures to 3,000 psi. For aircraft, industrial and armored equipment. (f) Flexible Lines, designed and fabricated to meet specific requirements.



① Typical CHIKSAN installation on hydraulic lines for aircraft landing gear.



② Brake line installation on torque link in aircraft brake system.

WRITE FOR CATALOG NO. 50-AH

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WELL EQUIPMENT MFG. CORP., HOUSTON 1, TEXAS

BALL-BEARING SWIVEL JOINTS FOR ALL PURPOSES

employment in 25 states. A single engine contains 14,000 parts, and the production of each part requires individual skills and plant facilities. Assembly of the engine will be at the Division's headquarters plant in South Philadelphia and at its new facility in Kansas City, Mo.

◆

Allied Metal Specialties Inc., 516 N. Charles St., Baltimore, Md., a recently formed company, has begun activity under the direction of R. E. Lee Mowbray, who was formerly associated with Cambridge Wire Cloth Co., Cambridge, Md., as manager of the fabricating division. The new company designs and fabricates all types of special fixtures from any metal or alloy. Complete facilities are available for the fabrication of plate, sheet, strip, wire, bars, and shapes. The company will specialize in equipment designed for high-temperature and corrosive applications.

◆

Baldwin-Lima-Hamilton Corp. has acquired the assets and business of the Austin-Western Co., Aurora, Ill. Austin will continue to serve its customers under its own name.

◆

Rosan Inc., South Gate, Calif., has opened a new foundry division. Th added foundry facilities will permi utilization of the patented Rosa molded-in-insert with protector ca in castings of specific design. Th foundry also will be engaged in a extensive research program directe mainly at testing new applications o the insert and developing new cast ing methods.

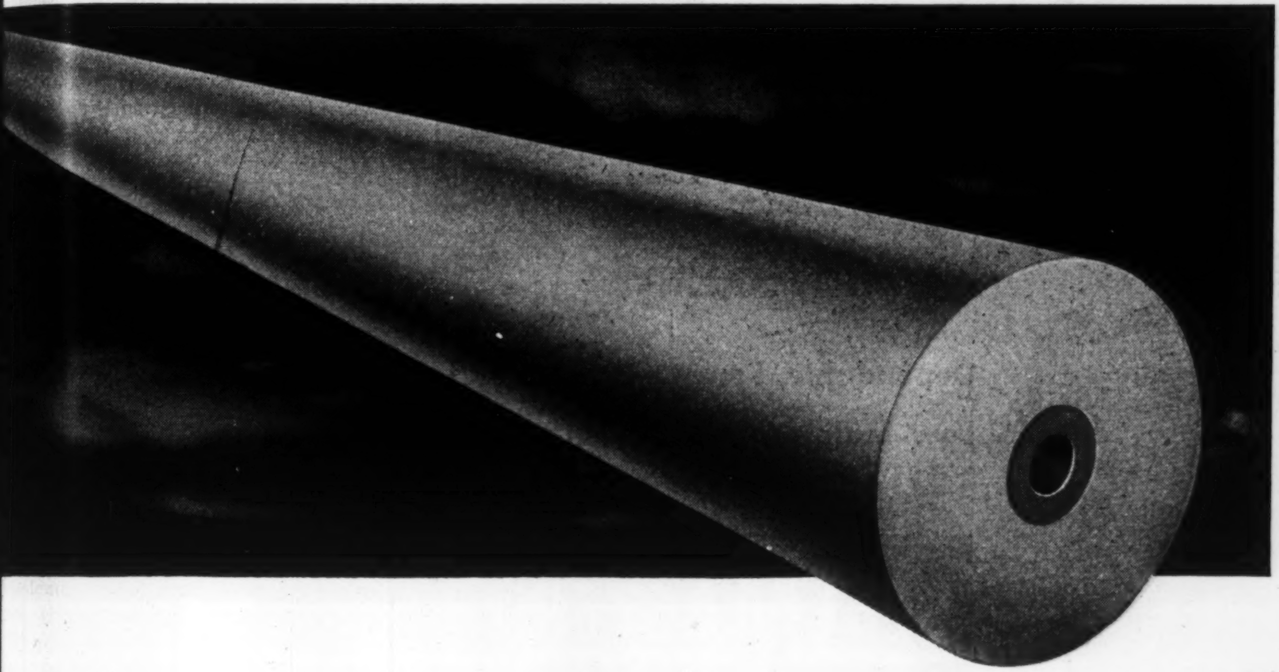
◆

Worthington Pump & Machiner Corp. has broken ground for a ve tical turbine pump plant at Succ sunna, N. J. The one-story plant wi be known as the Succasunna Wor of Worthington. It will be used manufacture vertical pumps to ser customers East of the Mississip River as well as customers abroa The vertical pumps are used for ge eral irrigation work, undergrou and surface water supply, and for i dustrial purposes such as lifting co mercial and aviation fuel from unde ground tanks.

◆

Nash-Kelvinator Corp. has receiv a letter contract from the U. S. Force to build large quantities Pratt & Whitney R-2800 "Dou Wasp" aircraft engines. The o is for the 18-cylinder radial air-co engine which develops about hp. The R-2800 is an advanced

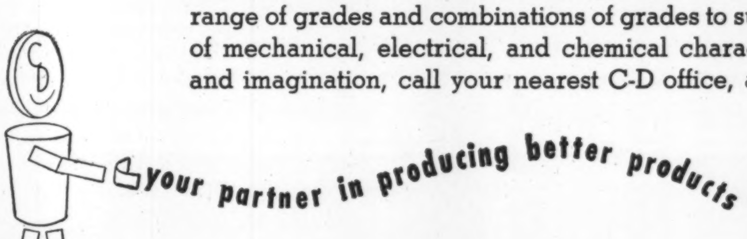
a product of imagination . . .



. . . with an ideal combination of electrical and mechanical properties

By working alongside folks like yourself—at design desks, workbenches, and in laboratories—we've acquired a good idea of the time, care, and imagination you pour into the engineering and production of your products. The thick-skinned insulation tube for an expulsion fuse shown here is a good example. The manufacturer wanted moisture resistance, high strength, weather resistance *plus* excellent arc resistance—all wrapped up in a material that was easy to machine. Working with him, and using a little imagination, C-D engineers came up with *two* different plastics: Laminated Dilecto Tubing for the wall, and Vulcanized Fibre for the core.

It's another example of how you, too, can depend upon C-D to engineer the right laminated plastic for your needs. For C-D has no "axe to grind." We can recommend from five basic plastics subdivided into a remarkably wide range of grades and combinations of grades to supply almost *any combination* of mechanical, electrical, and chemical characteristics. For *this* kind of help and imagination, call your nearest C-D office, any time.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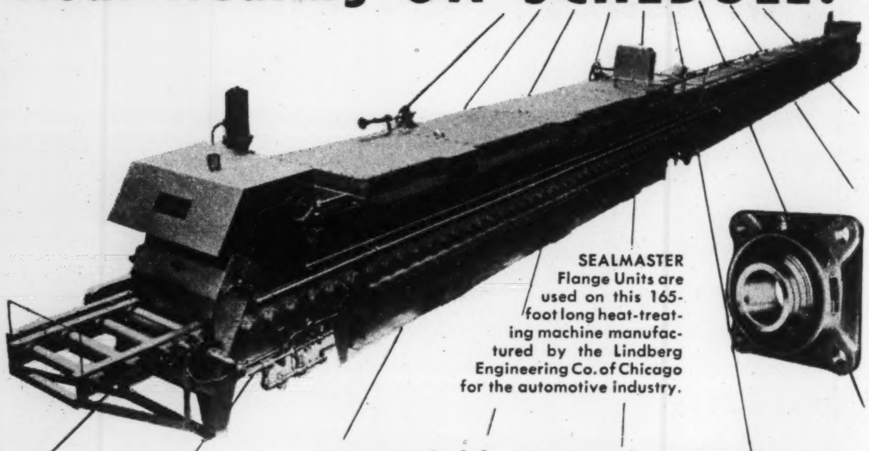
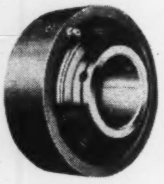
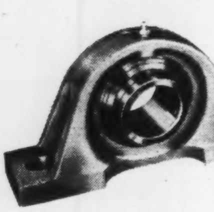
Heat-Treating ON SCHEDULE!

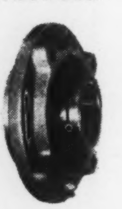

SEALMASTER Flange Units are used on this 165-foot long heat-treating machine manufactured by the Lindberg Engineering Co. of Chicago for the automotive industry.

Dependable, Smooth running Low-maintenance Operation *with*

SEALMASTER BALL BEARING UNITS


Cartridge Unit


Pillow Block


Flange-Cartridge Unit

Machines and equipment of all types give better and more economical performance when equipped with SEALMASTER Ball Bearing Units. Operating efficiency is greatly increased . . . and maintenance needs cut to an absolute minimum. Long-lasting, dependable service *under the most difficult conditions* is assured by SEALMASTER'S exclusive combination of features. The complete SEALMASTER line includes pillow blocks, flange, take-up and cartridge units.

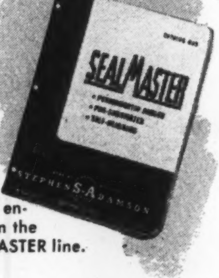
THESE *Proved Features* PAY OFF!

1. PERMANENTLY SEALED! Felt-lined steel flinger rotating in labyrinth prevents entry of dirt or loss of grease.

2. SELF-ALIGNING! Bearing unit with seals independent of housing, aligns itself without seal distortion.

3. PRE-LUBRICATED! Proper amount of lubricant is placed in bearing chamber before shipment . . . Unit is ready for immediate use.

4. NO HOUSING WEAR! Patented locking pin and dimple prevent rotation of outer race in housing and positions bearing for re-lubrication . . . No housing wear means quiet operation.



Get the facts! Write for your copy of Catalog 845 . . . It gives dimensions, load ratings and engineering data on the complete SEALMASTER line.

BEARING DIVISION
STEPHENS-ADAMSON MFG. CO.
18 Ridgeway Ave., Aurora, Ill. Los Angeles, Calif. • Belleville, Ont.

Factory Representatives and Dealers in All Principal Cities

sion of the World War II type an is used in Air Force trainers an cargo planes and Navy fighter trainers and cargo craft. A larg building program will supplement ex isting Nash-Kelvinator factory facili ties. The engines will be assemble in Kenosha, Wis., and tested in th facilities built there for World War I production. Some component part will be manufactured in existin plants in Kenosha and Milwaukee.

◆

Monsanto Chemical Co. is negotiat ing with the United States Pipe an Foundry Co., Burlington, N. J., fo the purchase of a 115-acre site an several buildings in Addyston, O. Th new plant, located on the Ohio Rive and abutting the city limits of Cin cinnati, O., will be operated as part of the company's Plastics Di vision. Initial operations of the nev plant call for production of Lustre styrene molding materials and Res inox phenolic resins. Installation o equipment will begin as soon as pur chase negotiations are completed production is expected early nex year.

◆

Cannon Electric Co. is the ne name of the Cannon Electric Devel opment Co., Division of Cannon Mfg Corp., Los Angeles, Calif., manufac turer of electrical plugs and signa equipment. The change in name i for simplicity and brevity.

◆

American Type Founders Inc., ha begun delivery to the Army of 76 mm guns under its contract to ar the new 25-ton General Walker Bull dog light tanks.

◆

Cummins Engine Co., Columbus Ind., is expanding. A new Store Center building with 92,000 sq ft an an extension of 9600 sq ft to its ol DD Fuel Pump building will bring t 60 per cent the five-year increase o Cummins lightweight diesel engin production capacity. The expendi ture during this period has totale $6,000,000.

◆

HPL Mfg. Co., engaged in th short-run stamping business, ha moved to a new and larger plant a 15210 Miles Ave., Cleveland, O.

◆

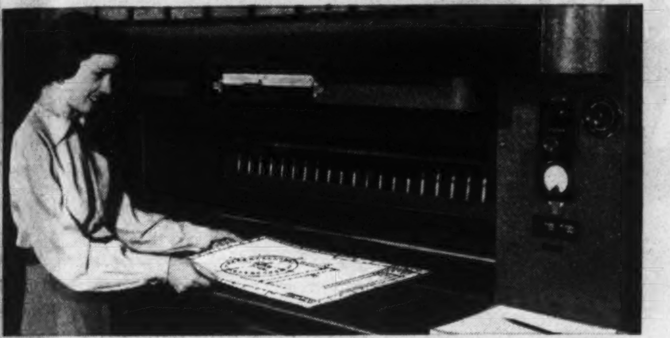
Janette Mfg. Co., Chicago, Ill., ha purchased the subfractional gearmo tor business of Robbins & Myers Inc Springfield, O. Manufacturer of mo tors, gearmotors, rotary converter and motor-generators, Janette recent

Announcing

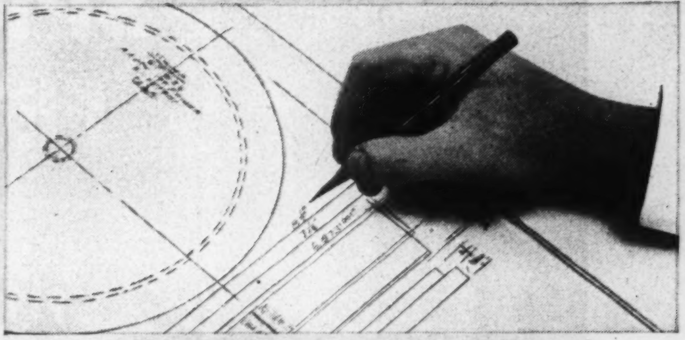
Kodagraph Autopositive Paper

Translucent

a new photographic intermediate material that speeds up print-making . . . drafting



30% *more translucent* than "regular" Autopositive —for faster quantity-print production



So *translucent* . . . you can easily read details on opposite side

Here is a new type of Kodagraph Autopositive Paper . . . especially designed to give you increased speed in large-volume print production.

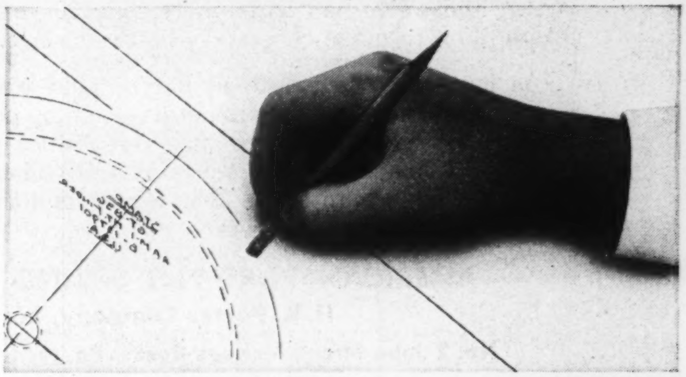
Like "regular" Autopositive, *Kodagraph Autopositive Paper, Translucent* can be handled in room light . . . prints directly to a positive in familiar reproduction equipment . . . is processed in standard photographic solutions. It reproduces original detail sharply, crisply . . . and its dense black photographic lines will not fade, smudge, or wear off.

But this new paper has an important "extra" which you'll spot at first glance—*an entirely new base* . . . remarkably translucent . . . remarkably durable.

Its 30% extra translucency enables you to turn out sparkling blueprints or direct-process prints faster, which lowers production costs considerably in large-volume work. *And it makes practical and convenient* the general use of "reverse-reading" intermediates (which assure final prints of top quality).

Its extra durability simplifies the handling of larger-size sheets . . . offers increased resistance to wear and tear in print-making and drafting.

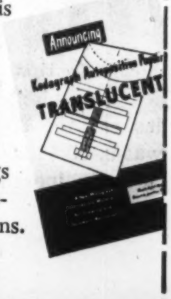
Reverse-reading intermediates, while better for print-making, used to be a problem in the drafting room. But no longer! Now the draftsman simply turns this highly translucent paper over . . . reads through the back—sees every detail sharp and clear. Additions, when necessary, are also made on this side.



Another drafting "PLUS." Unwanted detail can be removed from an Autopositive Translucent print in seconds with an ordinary eraser, without appreciable effect on the base, when the area involved is moistened slightly.

MAIL COUPON TODAY

. . . for full details on Kodagraph Autopositive Paper, Translucent. Intermediates on this new paper (which you or your commercial blueprinter can make) may well prove the key to important savings in your drawing reproduction operations.



EASTMAN KODAK COMPANY, INDUSTRIAL PHOTOGRAPHIC DIVISION 19
ROCHESTER 4, N. Y.

Gentlemen: Please send me a copy of your new free folder describing Kodagraph Autopositive Paper, *Translucent.*

Name____________________ Position__________

Company____________________

Street____________________

City____________________ State__________

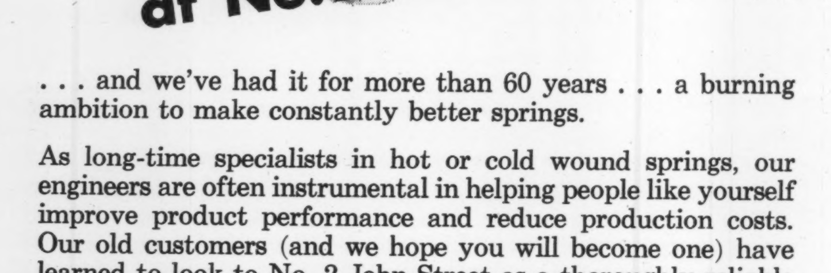
Kodak
TRADE-MARK

No. 2
SPRING FEVER
Yes, we've got SPRING fever
at No. 2 JOHN STREET

. . . and we've had it for more than 60 years . . . a burning ambition to make constantly better springs.

As long-time specialists in hot or cold wound springs, our engineers are often instrumental in helping people like yourself improve product performance and reduce production costs. Our old customers (and we hope you will become one) have learned to look to No. 2 John Street as a thoroughly reliable and unusually prompt source of supply.

AMERICAN-FORT PITT SPRING DIVISION
H. K. Porter Company, Inc.
No. 2 John Street, McKees Rocks, Pa. (Pittsburgh District)



AMERICAN-FORT PITT
SPRINGS

ly announced the expansion of its integral series in gearmotors. With th acquisition of the Robbins line, th company will be producing gearmotors ranging from 1/150 through 7½ hp. Janette has also purchased fiv acres of land in the Skokie suburba district of Chicago for the erectio of a one-story plant with 90,000 s ft of manufacturing area.

◆

Rockwell Mfg. Co. has organized separate division at its Freeport, Ill. plant to fabricate armor plate. Fabrication will involve several of th existing buildings of the company's Arcade plant and will be recognized as the Freeport Division. The Arcade Division will continue to produce wood and metal working powe tools.

◆

Foxboro Co. is completing a new one-story plant which will add 50,000 sq ft to its main plant in Foxboro, Mass. The new building will be used principally for the final assembly and testing of recorders and controllers for temperature, pressure, liquid level, and flow. Transfer of these operations from the older building wil permit expansion of departments which produce electronic and electrical instruments of other descriptions. In addition, a new training school building is being erected in the immediate vicinity.

◆

American Machine & Foundry Co. has acquired the ownership of the Cleveland Welding Co., Cleveland, O. through a $3,000,000 cash transaction. The demountable truck and tracto rims, bicycles and other circula welded products manufactured by Cleveland Welding will be added to the line of specialized and genera purpose machinery produced by AMF.

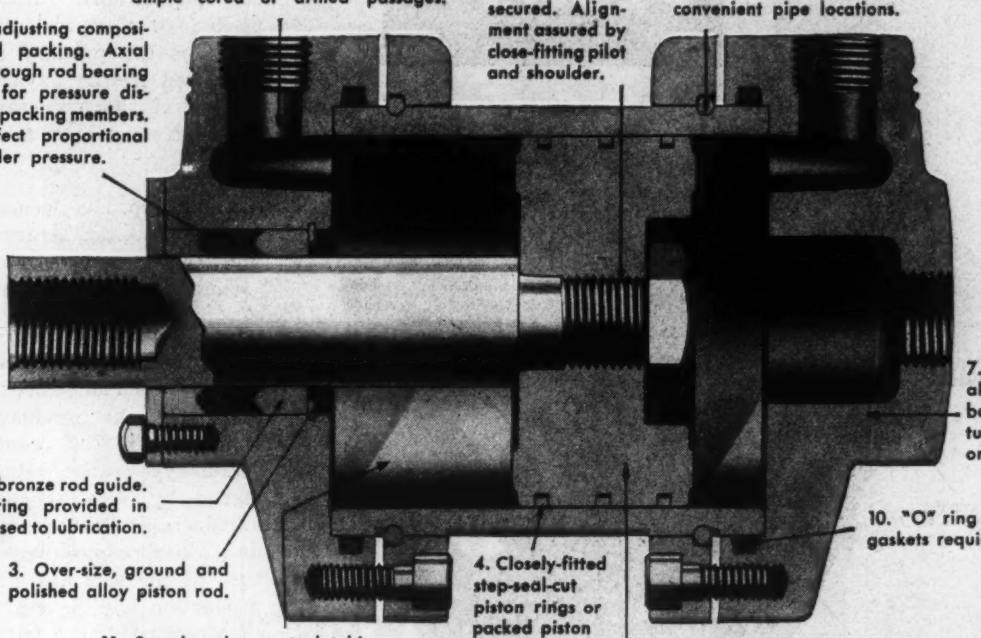
◆

Arrowhead Rubber Co., a subsidiary of **National Motor Bearing Co. Inc.,** at Downey, Calif., has taken a five-year lease on the building at 2350 Curry Ave., Long Beach, Calif. The company will transfer its aircraft duct division there. Acquisition of the new lease will add 27,000 sq ft of manufacturing space, more than triple the area now occupied by that division, and will release valuable space for the manufacture of oil seal parts and silicone rubber products.

◆

Air Reduction Co. Inc. is constructing a new plant at Calvert City, 15 miles east of Paducah, Ky. Costing upwards of $10,000,000, the plant will be used to increase the supply of de-

More Power to You



1. Self-adjusting composition rod packing. Axial holes through rod bearing provide for pressure disposal on packing members. Seal effect proportional to cylinder pressure.

2. Ample bronze rod guide. Rod bearing provided in area exposed to lubrication.

3. Over-size, ground and polished alloy piston rod.

4. Closely-fitted step-seal-cut piston rings or packed piston available.

5. Heavy-duty alloy cast pistons with large bearing surfaces.

6. Piston rod and assembly firmly secured. Alignment assured by close-fitting pilot and shoulder.

7. Heavy-duty alloy covers, bored to fit a turned diameter on tube.

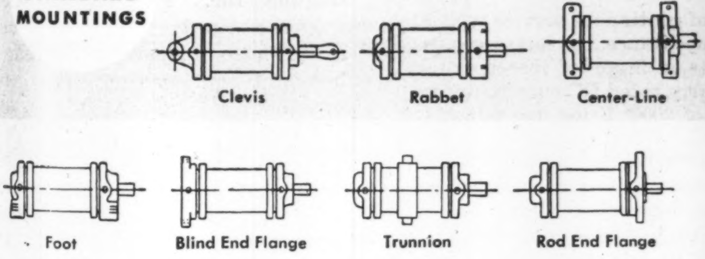
8. Large pipe connections, providing ample cored or drilled passages.

9. Keeper ring construction eliminates tie rods and permits rotation of covers to convenient pipe locations.

10. "O" ring seals. No gaskets required.

11. Seamless drawn steel tubing, precision honed.

SEVEN STANDARD MOUNTINGS



. . with RIVETT HYDRAULIC CYLINDERS

You'll find the performance of Rivett hydraulic cylinders close to foolproof. Designed with the utmost simplicity, they have no tie rods — keeper ring design permits covers to be rotated to convenient pipe connections and installation made in a minimum of space. External "O" rings are used as static seals to eliminate gaskets and assure leakproof operation. Sealing efficiency improves with increased pressure. Closely fitted automotive type piston rings reduce friction to a minimum.

Available in three pressure ranges: to 300 P.S.I. maximum and 1500 P.S.I. maximum service with standard models. 3000 P.S.I. maximum and higher services furnished on application. Seven standard mountings, in 10 bore diameters, in any stroke up to 96″, with standard size or 2:1 over-size piston rods, cushioned rod end, blind end or both. Special covers supplied. Send for Catalog Section 104.

RIVETT LATHE & GRINDER, Inc.
DEPT. MD 5 BRIGHTON 35, BOSTON, MASSACHUSETTS

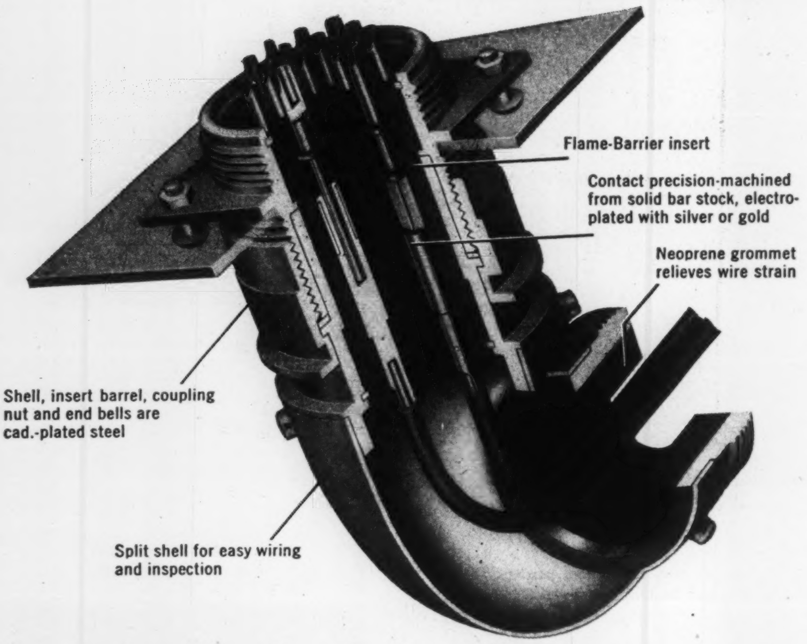
RIVETT furnishes a complete power package

VALVES • CYLINDERS • POWER UNITS

Air and Hydraulic
All sizes and types

Here's why those in the know

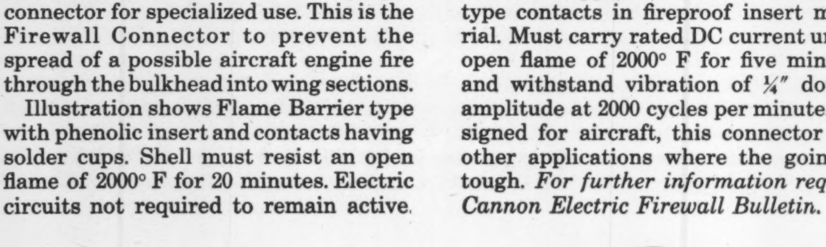
—demand **CANNON PLUGS**


Flame-Barrier insert
Contact precision-machined from solid bar stock, electro-plated with silver or gold
Neoprene grommet relieves wire strain
Shell, insert barrel, coupling nut and end bells are cad.-plated steel
Split shell for easy wiring and inspection

Here is another example of the care Cannon Electric takes in developing a connector for specialized use. This is the Firewall Connector to prevent the spread of a possible aircraft engine fire through the bulkhead into wing sections.

Illustration shows Flame Barrier type with phenolic insert and contacts having solder cups. Shell must resist an open flame of 2000° F for 20 minutes. Electric circuits not required to remain active.

The Fireproof continuous service type is similar in appearance, but has crimp-on type contacts in fireproof insert material. Must carry rated DC current under open flame of 2000° F for five minutes and withstand vibration of ¼" double amplitude at 2000 cycles per minute. Designed for aircraft, this connector has other applications where the going is tough. *For further information request Cannon Electric Firewall Bulletin.*



Cannon Electric AN Type Aircraft Firewall Connectors are available in 14 diameters with a large variety of insert arrangements in both Flame Barrier and Fireproof Types.

CANNON ELECTRIC

Since 1915

Los Angeles 31, California

REPRESENTATIVES IN PRINCIPAL CITIES

In Canada and British Empire: Cannon Electric Co., Ltd., Toronto 13, Ontario. World Export (Excepting British Empire): Frazar & Hansen, 301 Clay Street, San Francisco, California.

fense-vital calcium carbide and will be operated by the **National Carbide Co.,** one of Air Reduction's ten operating divisions. With an initial rated capacity of 142,500 tons of calcium carbide annually, the installation will consume more than 1,000,000 kilowatt hours of TVA electricity per day (enough to meet the normal requirements of a city of 250,000 population). Lime and coke needed to produce calcium carbide, which is the primary source of the fuel used in the oxyacetylene welding and cutting processes, will be imported from nearby areas.

◆

Thor Corp. has licensed Catita, SA, of Buenos Aires, Argentina, to make and sell the Thor spinner washer (semiautomatic) in that country.

◆

Westinghouse Electric Corp. has been awarded an $8,500,000 Navy contract for the production of radar equipment. The contract is for search-type radar sets recently designed by Westinghouse electronics engineers at Baltimore, Md. Tooling and other preparations for manufacture of the sets has already started; production will be carried out in an area now used as a warehouse so that current production of electrical appliances will not be affected.

◆

Magline Inc., Pinconning, Mich., has opened a new magnesium foundry division to increase its output of lightweight equipment for the materials handling field. Magline is also investigating the possibility of placing its magnesium sand casting design and production experience and facilities at the disposal of plants producing military equipment. The company will supply additional information to interested defense contractors.

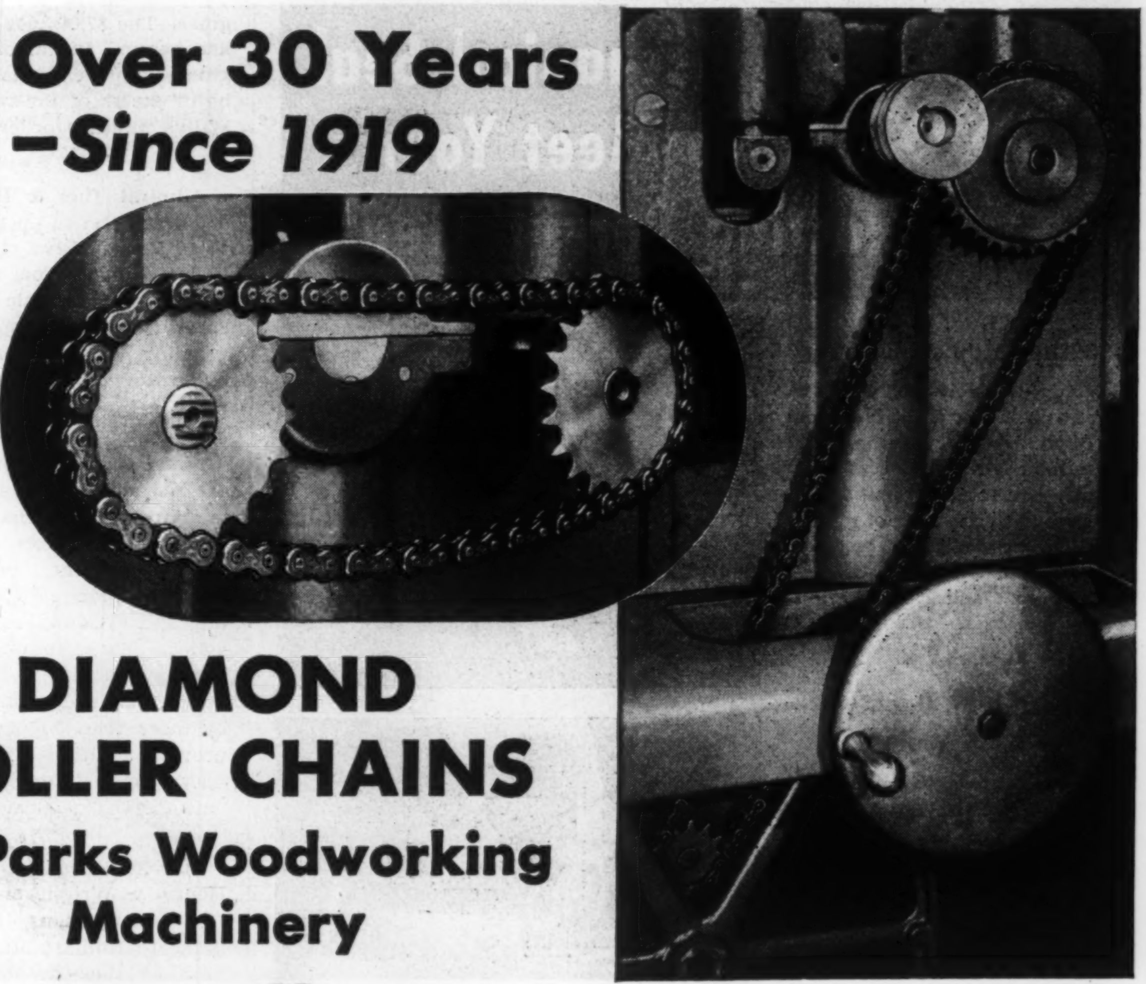
◆

Cooper - Bessemer Corp. has received an engine contract to build 40 of its largest supercharged gas engines for **Reynolds Metals Co.'s** new aluminum reduction plant near Corpus Christi, Tex. The engines, which develop 3700 hp will be delivered in total by January, 1952.

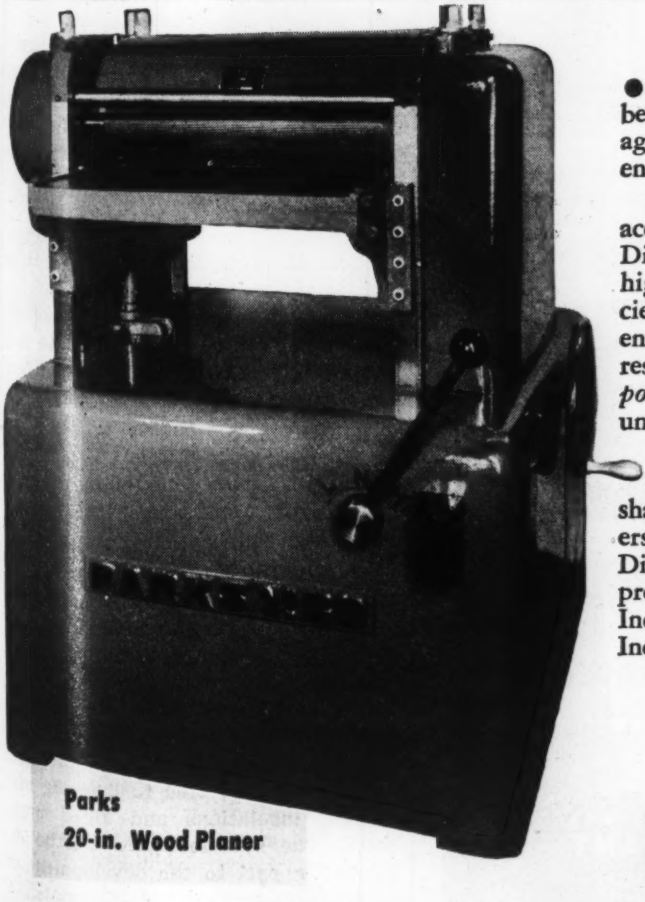
◆

Willys-Overland Motors Inc. has completed the purchase of the 13-acre Chevrolet plant at Anderson, Ind. Willys is proceeding under a letter of intent, in co-operation with the **General Electric Co.** and the U. S. Air Corps, to reconvert and reequip the 226,000 square feet of floor space for the production of major

For Over 30 Years —*Since 1919*



DIAMOND ROLLER CHAINS on Parks Woodworking Machinery



Parks
20-in. Wood Planer

● Many leading makers of woodworking machines began using Diamond Roller Chains regularly as long ago as 1894. There are many reasons for this preference for Diamond.

The proper heat-treatment of each roller chain part according to the function the part will perform gives Diamond Roller Chains a "resistance to wear" of the highest degree. They assure long life and high efficiency under unfavorable operating conditions—presence of moisture, fumes, etc. They have the great reserve strength to absorb shock loading. They are *positive,* transmitting 100 per cent of the speed at unvarying ratios.

Throughout the lumber and woodworking industry for plant motor and engine drives—from shaft to shaft—on saws, trimmers, rolls, transfers, sanders, lumber carriers, hoists and portable sawmills—Diamond Roller Chains have contributed much to improve production. DIAMOND CHAIN COMPANY, Inc., Dept. 435, 402 Kentucky Ave., Indianapolis 7, Indiana.

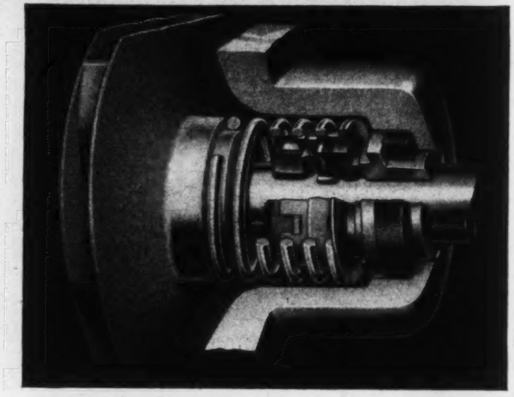
Offices and Distributors in All Principal Cities

DIAMOND **ROLLER CHAINS**

There's a JOHN CRANE Mechanical Seal To Meet Your Exacting Requirements

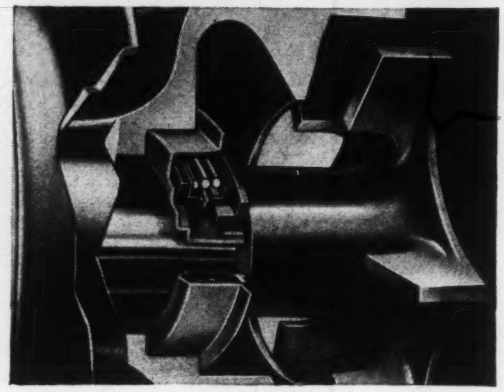
General Purpose Seal...

... most widely used end-face seal in industry ... ideal for centrifugal, rotary and jet pumps, gear reducers and many other rotary shaft applications ... offers long life, complete flexibility, easy installation. Two types available, No. 1 and 2, for varying equipment space conditions.



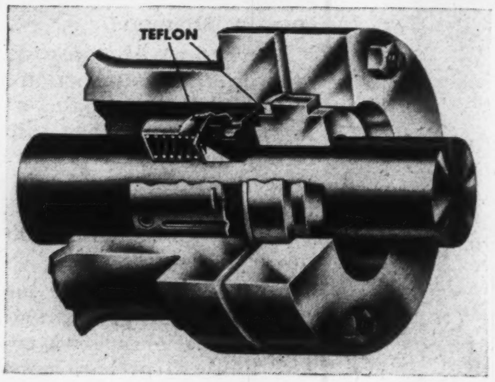
Low Cost, High Quality "Pressed-in" Seal...

... the answer to small shaft sealing applications involving high speeds and vibration. Millions of these Type 6A Seals are mass-produced for automotive water pumps, making them available at a relatively low cost in stock sizes. Each of these easy-to-install seals will fit several shaft sizes since they are "pressed-in" and do not touch the shaft.



High Temperature Anti-Corrosive Seal...

... This Type 9 Seal performs effectively at temperatures up to 485° F. It incorporates a *Teflon* flexible member which is unaffected by all known corrosive agents.



★ ★ ★

All seals in the "John Crane" line are end-face in design ... nothing touches the shaft which can score it. No matter what your mechanical sealing problem is, there's a "John Crane" seal designed to exactly "fill the bill". Our trained field engineers are ready to work with you in selecting the best seal for your needs.

Write for entirely new catalog on "John Crane" Mechanical Seals. It's just off the press!

Dept. MD-5, 1825 Cuyler Avenue, Chicago 13, Illinois.

JOHN CRANE
PACKINGS AND MECHANICAL SEALS
CRANE PACKING COMPANY
CHICAGO
Offices in All Principal Cities in United States and Canada

components for the GE J-47 jet engines. The $7,000,000 tooling program has begun. Initial order for the engine components is understood to be in excess of the recent $63,000,000 Willys military order for Jeeps.

◆

Admiral Tool & Die Co. Inc. has acquired the Eppenbach plant at 45-10 Vernon Blvd., Long Island City, N. Y. Admiral Tool will continue the manufacture and sale of all Eppenbach emulsifying, mixing, homogenizing, grinding, and processing equipment under an exclusive licensing agreement.

◆

Metal Carbides Corp., Youngstown, O., has added 8000 sq ft to its plant making the total manufacturing area 35,000 sq ft. More than $100,000 of new equipment, including electric furnaces, machine tools, powder mixing, and crushing equipment is being added. These improvements will expand production of Talide tools, tips, dies, rolls, and wear resistant parts by more than 50 per cent as well as provide additional facilities for producing special tungsten carbide products for the defense effort.

◆

Hartford-Empire Co., of which Henry & Wright and V & O Press Co. are divisions, has changed its name to Emhart Mfg. Co. With Emhart as the parent company, there will be no change in the operation or organization of Henry & Wright, Hartford, Conn., which manufactures automatic presses, or the V & O Press Co., Hudson, N. Y., which produces punch presses, automatic feed attachments and special machinery.

◆

Cleveland Graphite Bronze Co. has borrowed $10,000,000 from the Metropolitan Life Insurance Co. for its expansion program relative to the national defense effort. The expansion program calls for the establishment of five new branch plants as soon as possible. The plants are to be located in small communities for reasons of dispersion, security and manpower supply.

◆

Johns-Manville Corp., in order to expand its defense activities, is constructing a new research building. The structure will be an addition to the J-M Research Center group near Manville, N. J., which is reputedly one of the largest research facilities in the world devoted to building materials, insulations and allied products. The new facilities will be directed in part to the development of substitutes for critical materials.

Since the OBERDORFER INTERNATIONAL Pumps described below are new, with no prior history of use, Washington expects a DEFENSE ORDER or equivalent for their purchase. Free samples are available to O.E.M. accounts.

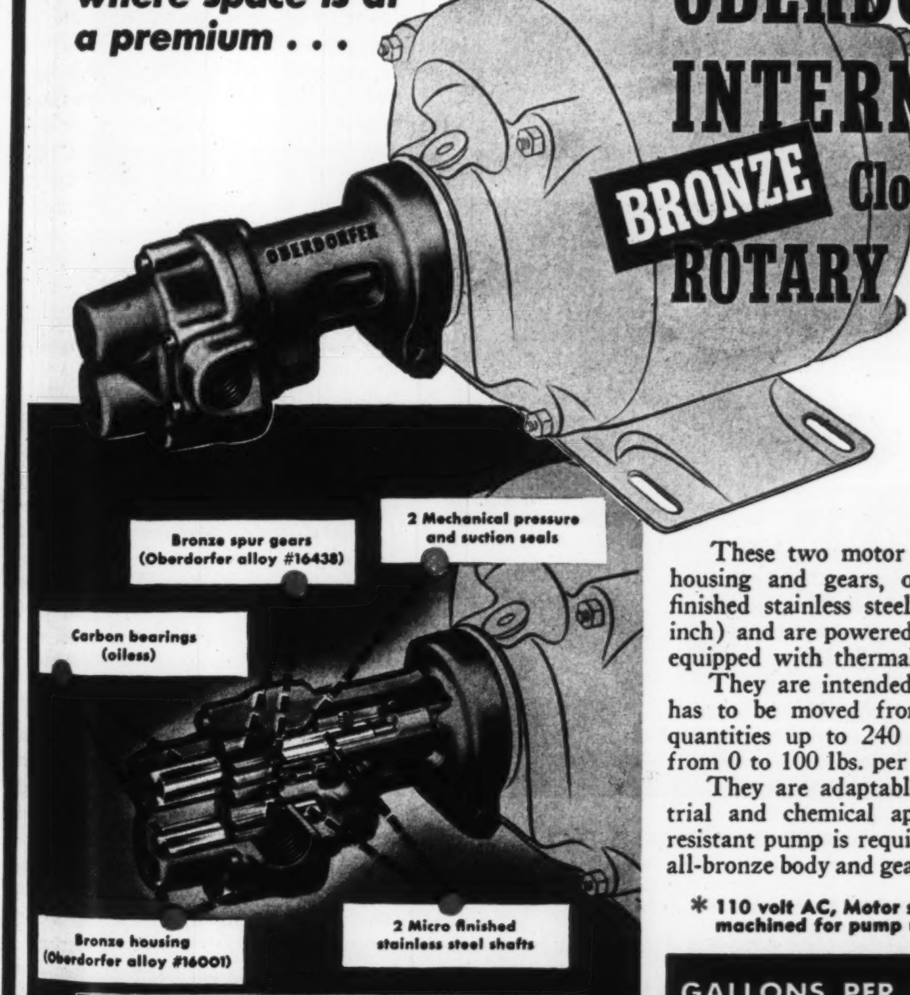
Introducing

The New Series 2

OBERDORFER INTERNATIONAL

BRONZE Close Coupled ROTARY GEAR PUMPS

For liquid transfer where space is at a premium . . .


OBERDORFER
Bronze spur gears (Oberdorfer alloy #16438)
2 Mechanical pressure and suction seals
Carbon bearings (oiless)
Bronze housing (Oberdorfer alloy #16001)
2 Micro finished stainless steel shafts

These two motor driven pumps have all-bronze housing and gears, oilless carbon bearings, micro-finished stainless steel shafts (± 25/100,000 of an inch) and are powered by heavy-duty ⅓ h.p. motors* equipped with thermal overload protection.

They are intended to be used wherever a liquid has to be moved from one location to another in quantities up to 240 gallons per hour at pressures from 0 to 100 lbs. per square inch.

They are adaptable for a wide variety of industrial and chemical applications where a corrosion-resistant pump is required and space is limited. Their all-bronze body and gears permit use with most liquids.

*** 110 volt AC, Motor standard but specially machined for pump mounting.**

DIMENSIONS—Pump Only

Pump No.	Height	Width	Length
No. 1½	2⅞	2 11/16	4¾
No. 2	3 11/16	2⅜	4⅞

PUMP No. 1½ CCC

Pump head only (⅜" pipe size)........................list $20.00
F.O.B. Syracuse
Complete unit with ⅓ H.P. 110 volt AC thermal overload motor..price on request

PUMP No. 2 CCC

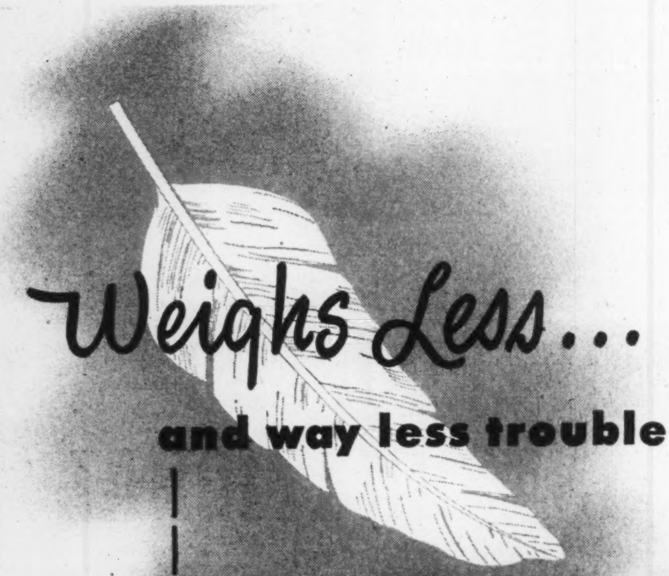
Pump head only (⅜" pipe size)........................list $22.50
F.O.B. Syracuse
Complete unit with ⅓ H.P. 110 volt AC thermal overload motor..price on request

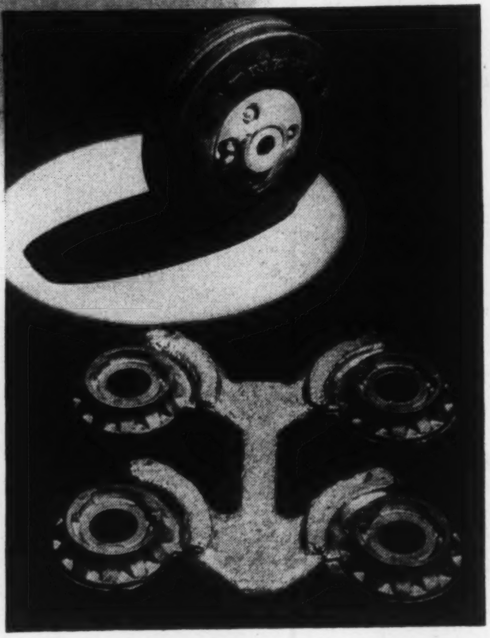
GALLONS PER HOUR at 1725 R.P.M.

Pressure	Pump No. 1½ CCC	Pump No. 2 CCC
0 lbs.	120 gal.	240 gal.
25 lbs.	110 gal.	220 gal.
50 lbs.	100 gal.	190 gal.
75 lbs.	95 gal.	170 gal.
100 lbs.	90 gal.	———

Write Dept. MD-515

INDUSTRIAL PUMP DIVISION
Oberdorfer Foundries, Inc.
Syracuse, N. Y.





because it's Well-Cast

This Well-Cast magnesium permanent mold wheel casting—a ¼ lb. light weight—reduces the overall weight of the hand truck on which it's used. Tough as an American in Korea, it's also a push-over to machine. Same thing applies to our sand castings in either magnesium or aluminum. Want to lose some weight?

40 Years' Experience

Well-made wood and metal patterns • If you would like to get the Wellman magazine each month, drop us a note on your business letterhead.

THE WELLMAN BRONZE & ALUMINUM CO.

2512 EAST 93rd STREET • CLEVELAND 4, OHIO

Society

ACTIVITIES

The **American Foundrymen's Society,** international technical society of the metal castings industry, has announced through its president, Walton L. Woody of the National Malleable and Steel Castings Co., a program to found a technical center for the producers of cast metals vital to national defense. More than $95,000 of the $100,000 goal has been raised by voluntary subscription from the Society's 9500 members. The center is to be established during the next two years in one of the principal Midwestern foundry centers.

◆

A Certificate of Co-operation has been presented to the **American Standards Association** by the Economic Co-operation Administration. The certificate was given in recognition of ASA's assistance and co-operation in helping technical missions from overseas to study U. S. standardization and simplification practices and techniques. Through its broad connections as the national clearinghouse for standards, ASA arranged plant visits and conferences for these missions.

◆

Steel Founders' Society of America is promoting a national conservation drive to help alleviate the critical supply situation in iron and steel scrap. Supplementing expanded conservation activities and revised materials handling practices throughout the steel casting industry, the Society is extending its program fostering intensive collection, segregation, and economical use of scrap in a three-way campaign.

◆

As the result of member industries moving faster than the Administration in preparing for defense production, the **National Metal Trades Association** is rapidly expanding its activities, services and staff. Joseph L. Kopf, president of the Association, has explained that an expansion program which has been underway for several months is the result of demands by present members, and an influx of new members, to help them prepare for national defense and avoid as many of the industrial problems associated with World War II as possible. To enable members to operate as efficiently as possible under the manpower and wage controls, the Association's Engineering Staff, which installs job and salary rating plans, has been increased in size and put on an accelerated schedule. Other working departments have also been expanded. The Research Department, drawing on World War I and II experiences, has been preparing and issuing a service of informational and advisory documents and bulletins on such subjects as Sabotage, Women in Industry, Manpower Mobilization, and Wage Stabilization. In addition, the Association has engaged a Washington counsel and installed a system whereby daily developments in Washington are relayed to member companies vitally affected.

◆

J. J. Demuth, president of the **American Society of Tool Engineers,** and general superintendent, Slido Inc., St. Louis, Mo., has been awarded an honorary membership in the **Institute of Production Engineers,** the British equivalent of the ASTE.

◆

The *Wright Brothers Medal* commemorating pioneer American efforts in flying has been awarded by the **Society of Automotive Engineers** to James C. Floyd of A. V. Roe Canada Ltd. Presentation was made at a dinner officially closing the National Aeronautic Meeting of the Society in New York. Floyd is the first citizen of any country other than the United States to receive the honor. The award was based specifically upon the excellence of a technical paper, "The Avro C-102 'Jetliner'," prepared and presented by Floyd before the SAE Annual Meeting, Detroit, Mich., January, 1950.

◆

New officers of the **American Society of Body Engineers,** elected during the meeting at the Detroit Leland Hotel, Detroit, Mich., are:

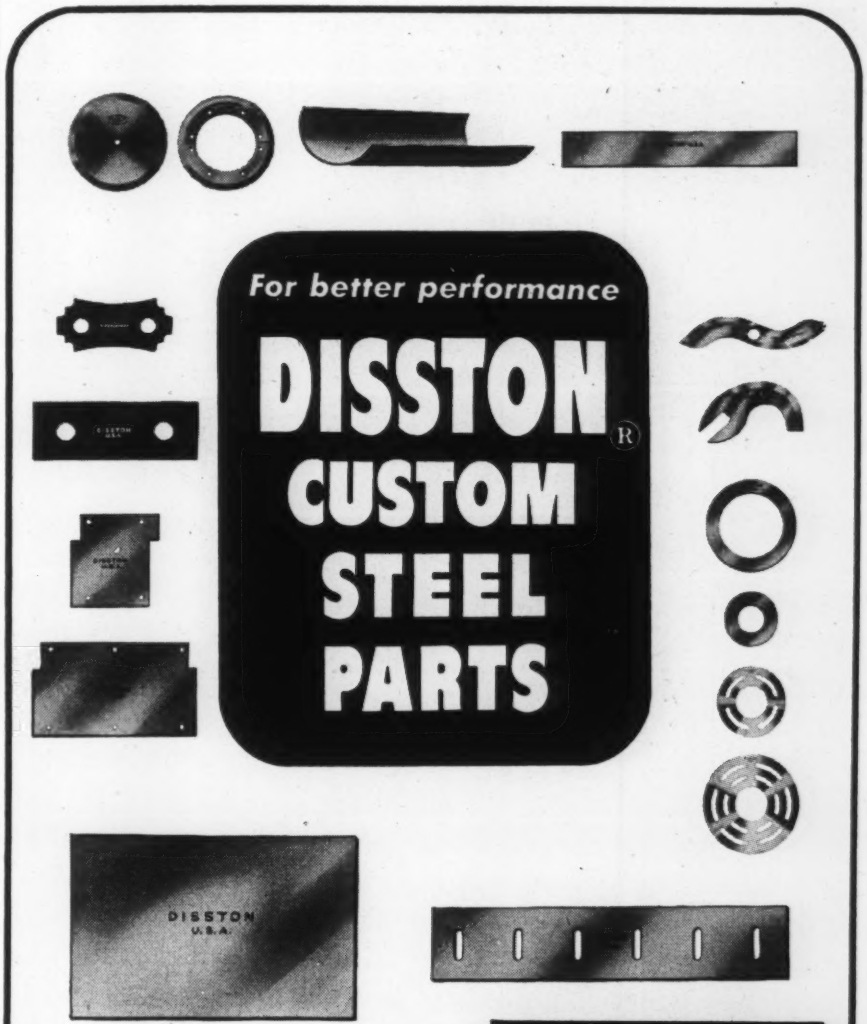
President—Harry G. Garman, Fisher Body

Vice President—Harold V. Atnip, Chrysler Corp.

Secretary—Gordon J. Lawton, Briggs Mfg.

Treasurer—Edward L. Pangborn, Chrysler Corp.

Trustees—I. Louis Carron, Carron Co.; Lynn A. Fill, Motor Products; William K. Norwick, Fisher Body; Charles Bugbee, Ford Motor Co.; Stanley C. Vahey, The Budd Co.; L. James Berridge, Woodall Industries; and Arthur L. Bradley, Creative Industries.



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WASTE
In peace waste is a sin...
NOW—waste is a crime!

Made to your blueprint requirements from

DISSTON SPECIFICATION STEELS

Intricate designs . . . exacting tolerances . . . special heat treating . . . odd shapes and unusual sizes—you can get them made better—at less cost—by Disston!

Disston Custom Steel Parts are any replaceable heat-treated products which are made from flat steel, hardened, tempered, and machined. Disston facilities include those for grinding plates up to 100″ long, 65″ wide; circular work from 15/16″ diameter to 72″ diameter.

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VALUABLE BOOKLET

on Disston Custom Steel Parts shows how to save on vital parts and materials; how to improve performance of machines and products; tells how to specify and order for most economical purchasing. A "must" reference book for the designer, engineer, purchasing agent. Sent free without obligation. Write on your letterhead or use coupon!

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4
CYCLE
BRIGGS & STRATTON
GASOLINE
ENGINES
World Wide
FACTORY
SUPERVISED
SERVICE

Preferred power for garden tractors and a wide range of other agricultural equipment — the world's most widely used single-cylinder gasoline engines on machines and tools for industry, construction, railroads, oil fields, etc., and on appliances and equipment for farm and home.

“PREFERRED POWER” for home, farm, and industrial equipment — powered by gasoline engines. Briggs & Stratton Corporation, Milwaukee 1, U.S.A.

In the automotive field Briggs & Stratton is the recognized leader and world's largest producer of locks, keys and related equipment.

SALES AND SERVICE

Personnel

KEY changes in the Eastern sales staff of Acme Steel Co. were announced recently. **George E. Helm** has been promoted to the position of sales manager of a new district in Baltimore and will also serve as liaison with government bureaus in Washington, D. C. **Charels E. Klinck** has been appointed Philadelphia district sales manager, replacing **Charles J. Bruneel,** who enters semi-retirement until completing his 33-year span of service in October. Coincident with this appointment, the Philadelphia office is moving from 401 North Broad St. to 5667 Ogontz Ave. **Bruce E. Cunningham** has been assigned to the newly-created position of area special representative. Operating from headquarters in New York City, he will render specialized services to customers throughout the Eastern area.

◆

A. F. Vinson, manager of General Electric Company's welding divisions at Fitchburg, Mass., has temporarily relinquished his duties in order to attend the Advanced Management Program's Business Training Course at the Harvard Graduate School of Business Administration. To assume Mr. Vinson's responsibilities during his absence, **R. C. Freeman** has been named acting manager of the welding divisions.

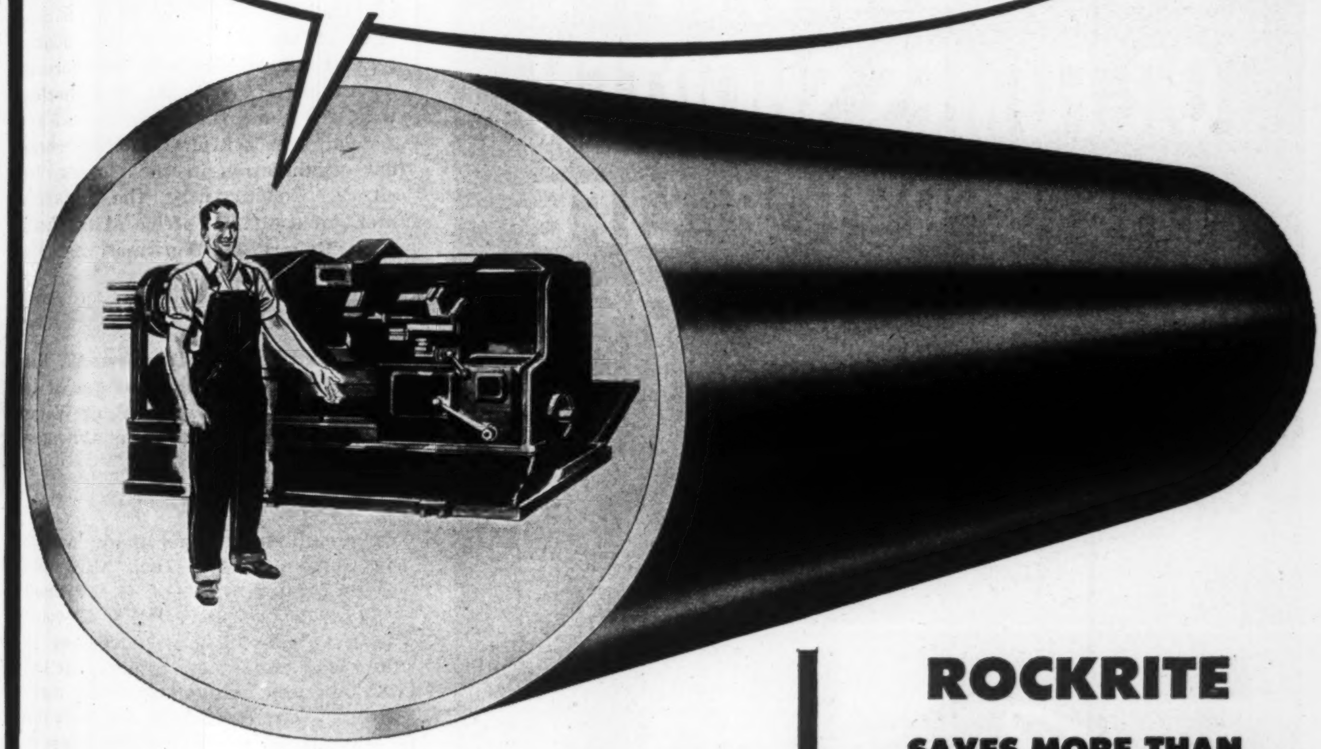
◆

The abrasive and diamond wheel department of Manhattan Rubber division of Raybestos-Manhattan Inc., Passaic, N. J., has announced that **Kenneth A. Tamms** has joined its staff as sales engineer for Wisconsin, with headquarters in Milwaukee. He succeeds **Alex Watchorn,** who has retired. At the same time it was announced that **P. H. Hagen** of Seattle, Wash., has joined the company's West Coast sales division, with headquarters at 2221 Fourth Ave., South, Seattle, Wash.

◆

Paul Reeves has been appointed director of sales for The Timken Roller Bearing Co. Joining the company in 1929 after completing its engineering training course, he served as sales engineer in the Chicago office and was subsequently transferred to the San Francisco branch office

There's an extra machine in *this* tubing!

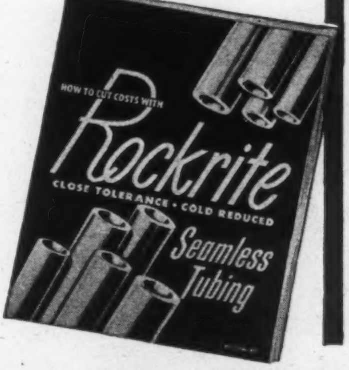


Is production the problem? You can step up output of ring-shaped and cylindrical parts as much as 100% by machining them from Rockrite Tubing. Result . . . ? *One* automatic screw machine does the work of *two*. It's like adding an extra machine to each one on your line. What's more, costs of parts made go down as much as 50%.

That's because Rockrite Tubing is *compression-sized* to much closer tolerances than standard mechanical tubing. With Rockrite, there's less metal to cut, less finishing. Work goes faster.

NEW 16-PAGE BULLETIN

tells how the unique Rockrite process provides greater tube accuracy which multiplies *production of machined parts and* subtracts *costs. Write for your copy today.*



HOW TO CUT COSTS WITH

Rockrite

CLOSE TOLERANCE • COLD REDUCED

Seamless Tubing

ROCKRITE®

TUBING

ROCKRITE

SAVES MORE THAN ANY OTHER TUBING

- **Higher cutting speeds**
- **Tools last longer between grinds**
- **Work-surface finishes are better**
- **Machined parts have closer tolerances**
- **Stations on automatics are often released for additional operations**
- **Extra-long pieces available—less down-time for magazine stocking and fewer scrap ends**
- **Closer tolerances often eliminate necessity for machining on outside or inside**

TUBE REDUCING CORPORATION • WALLINGTON, NEW JERSEY TR-121A

DON'T LET DUST, DIRT, LINT OR FUMES SHORTEN THE SERVICE LIFE OF YOUR MOTORS

BALDOR ELECTRIC

Streamcooled [illegible] BEARING MOTORS

[illegible] TOTALLY ENCLOSED, cooled by an outer [illegible] cannot lodge dust, dirt, lint, or [illegible] to clog up and [illegible]

BALDOR Streamcooled Motors require no dismantling for cleaning. Thus LESS SERVICING . . . no interruption of production or service. Let us tell you more about these long service-life BALDOR Motors.

BALDOR ELECTRIC CO. • ST. LOUIS 10, MO.

Baldor

MOTOR SPECIALISTS FOR 30 YEARS

Baldor Motors are sold and serviced in more than 200 trade centers

where he was made industrial district manager. He returned to Canton as sales promotion manager i 1940, and when this country entere the war, he was put in charge o government priorities to handle contacts between the company an Washington.

◆

Clinton O. McNeer, Chicago district sales manager for the chemica division of The Goodyear Tire & Rubber Co., has been named sales manager of the division with headquarters at Akron. He will be succeede at Chicago by **J. A. Weatherford** who, for some time, has served as special representative at the chemical organization in the Chicago territory. Concurrently the establishment of a district office at St. Louis with **Robert E. Workman** as manager, was announced.

◆

Appointment of **Andrew W. Ros** as assistant general manager of the Warner Gear division of Borg-Warne Corp., at Muncie, Ind., was announced recently.

◆

Announcement was made recentl by Cutler-Hammer Inc., Milwauke of the appointment of **O. P. Prou foot** as manager of the Clevela district sales office, succeeding th late R. J. Eckstein. Joining the Cutler-Hammer student training course in 1928, Mr. Proudfoot has served in various sales capacities, the most recent one being with the Buffalo district sales staff. As manager of the Cleveland office, he will supervise the sale of motor controls, steel mill equipment and allied electrical apparatus in that area.

◆

L. W. Mercer has been elected to the new executive vice president post for the Square D Co. Formerly vice president and general manager of the switch and panel division in Detroit, Mr. Mercer will now assume overall responsibility for direction and co-ordination of the company's sales, engineering and production activities. At the same time **F. H. Roby** was elected vice president in charge of sales and director. Having joined the Square D organization in 1933, he has served as field engineer, headquarters application engineer, manager of industrial control sales and general sales manager. **L. G. Maechtlen** has been elected vice president and director. He has served as Los Angeles plant works manager, Los Angeles territory manager and Western sales manager. He will continue

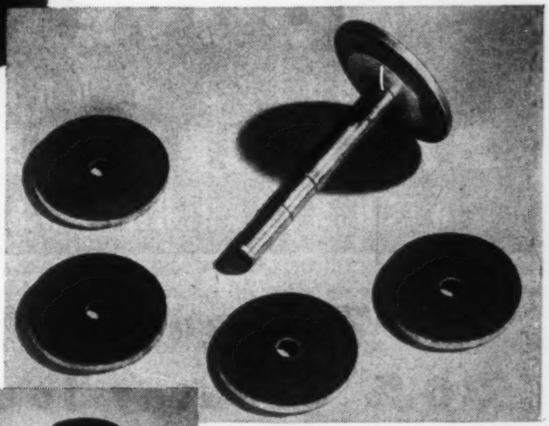
What's U. S. Rubber doing for electrical design?

Transformer handle made of Enrup for a large manufacturer of electrical equipment. Enrup was selected because its electrical properties can be maintained under very adverse conditions, and because it has great toughness, impact strength, and resistance to other solvents. Enrup has been so successful that the manufacturer intends to use it for other phases of transformer design and construction.

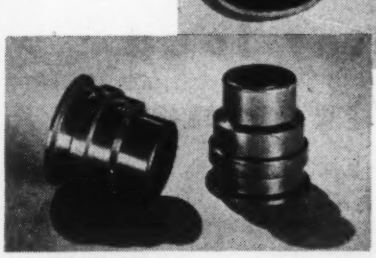
The horizons of electrical design are being widened by U. S. Rubber's new thermosetting plastic, Enrup. The transformer handle shown here has greater strength and electrical properties because it is made of Enrup.

This remarkably versatile substance can be punched, sanded, sawed, nailed, bolted, molded or machined. Enrup can be made into almost any shape or form, simple or complex. It may be exactly what you have been looking for to make your product stronger, more efficient, less expensive.

Enrup is fabricated and molded entirely by U. S. Rubber engineers. They will gladly discuss your particular problems. Write to address below.



Pump valve seat made of Enrup because Enrup resists swelling or deterioration caused by gasoline, and because it resists compression set or deformation over a wide range of temperature conditions.



This printing roll-end bearing demonstrates Enrup's high adaptability to precision molding techniques. It has high dimensional stability and resistance to corrosion caused by photographic solutions.

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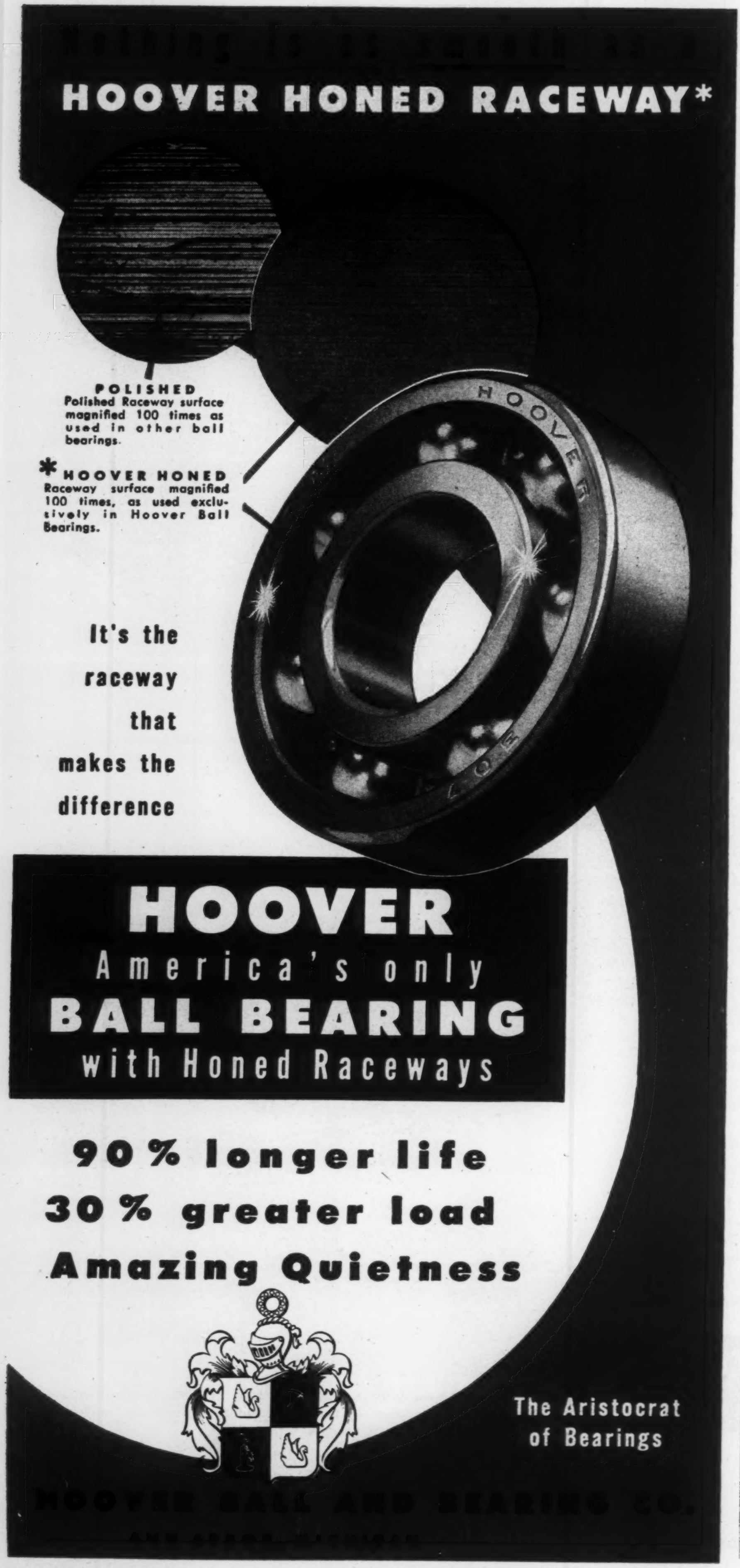
SERVING THROUGH SCIENCE

UNITED STATES RUBBER COMPANY
MECHANICAL GOODS DIVISION • ROCKEFELLER CENTER, NEW YORK 20, N. Y.



Nothing is as smooth as a

HOOVER HONED RACEWAY*

POLISHED
Polished Raceway surface magnified 100 times as used in other ball bearings.

***HOOVER HONED**
Raceway surface magnified 100 times, as used exclusively in Hoover Ball Bearings.

It's the
raceway
that
makes the
difference

HOOVER
America's only
BALL BEARING
with Honed Raceways

90% longer life
30% greater load
Amazing Quietness

The Aristocrat
of Bearings

HOOVER BALL AND BEARING CO.
ANN ARBOR, MICHIGAN

in this latter position and as assistant to **J. H. Pengilly,** vice president and general manager of the Western division. Messrs. Mercer and Roby are both located in the company's executive offices in Detroit, while Mr. Maechtlen remains based at the Western division headquarters in Los Angeles.

◆

Raymond E. Otto has been elected vice president and general sales manager of The Emerson Electric Mfg. Co., St. Louis. A veteran of 37 years with the company, Mr. Otto served as a sales correspondent and field engineer before being named assistant manager of motor sales in 1928. Eight years later he became manager of motor sales and in 1939 was appointed manager of sales. During World War II he was transferred to the turret division, then returned to the electrical division in 1945 as general sales manager.

◆

Formerly assistant manager, **Ralph E. Donnelly** of Fitchburg, Mass., has been appointed manager of the Fitchburg turbine sales division of the General Electric Co. The company has also recently announced the appointment of **D. S. MacDonald** as sales manager of a newly created gearmotor section of the gearmotor and packaged drive division.

◆

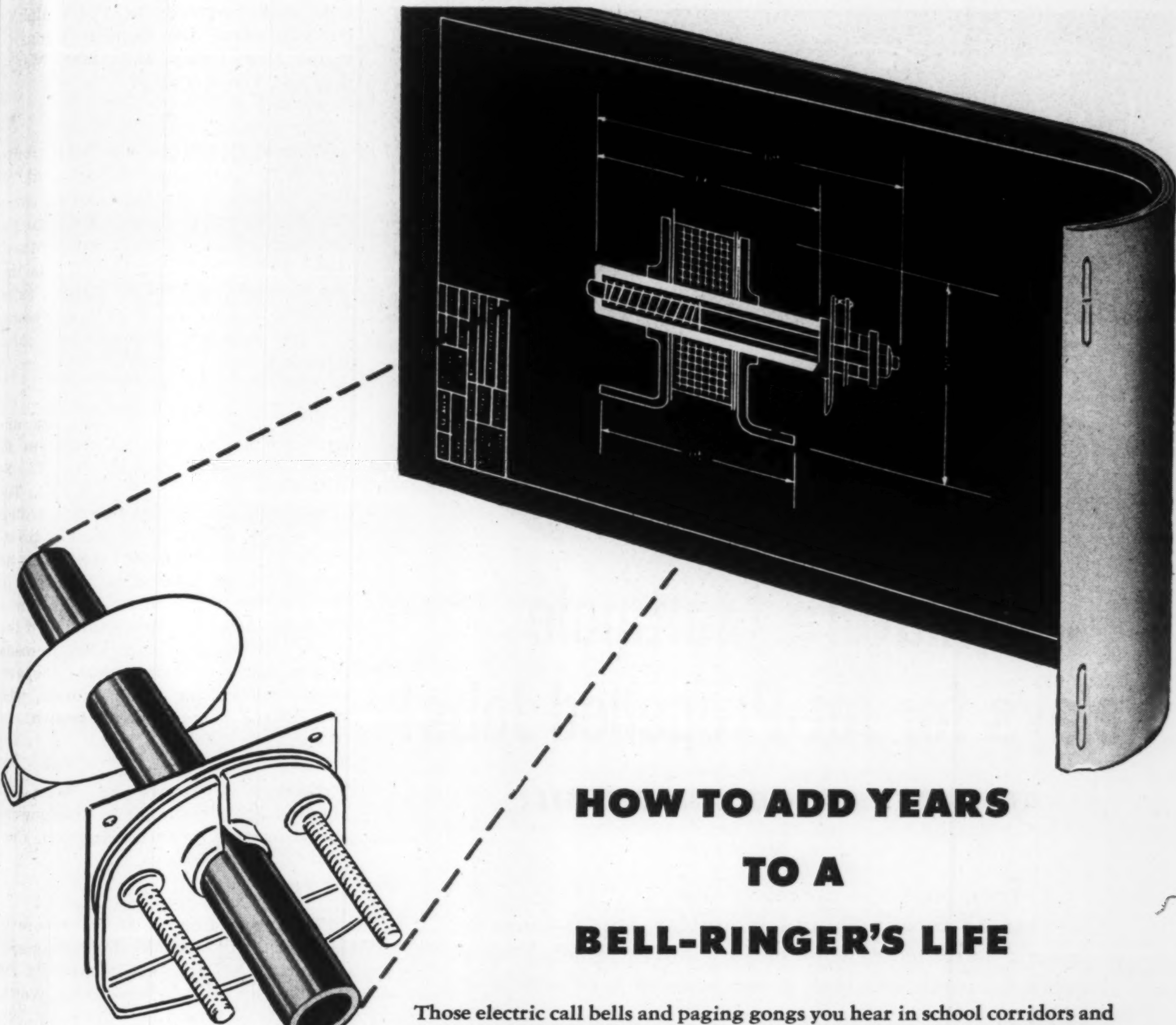
Robert B. Moir, formerly of Foote Bros. Gear and Machine Corp., is now affiliated with the W. A. Jones Foundry & Machine Co.

◆

Link-Belt Co. has announced that **Harry G. Andersen,** heretofore district sales engineer at Milwaukee, has been appointed district manager at Birmingham, with headquarters in the Comer Bldg., 2100 Second Ave. North. Mr. Andersen began his Link-Belt career in 1937 at the company's Pershing Road plant in Chicago, where he served in various capacities in the engineering department and Chicago district sales. He was transferred to Milwaukee in 1948.

◆

To represent the company in Dallas, Tex., **M. L. Sheehan** has joined The Parker Appliance Co., Cleveland, as industrial sales engineer. He will serve industrial firms of the South Central states in the application engineering of Parker tube fittings, valves, O-rings, and other products for industrial hydraulics, instrumentation and fluid handling. To serve in a similar capacity, **Raymond B. Jewett** has been appointed as indus-



HOW TO ADD YEARS TO A BELL-RINGER'S LIFE

Those electric call bells and paging gongs you hear in school corridors and factories lead busy lives . . . they're working during every hour of the day.

To combat rapid wear in the operating mechanism, Sperti Faraday, Inc., switched to Republic ELECTRUNITE Stainless Steel Tubing for the plunger tube of the actuating solenoid. The life of this heart of the device has been doubled by the shift from a non-ferrous tube to Republic ELECTRUNITE Stainless.

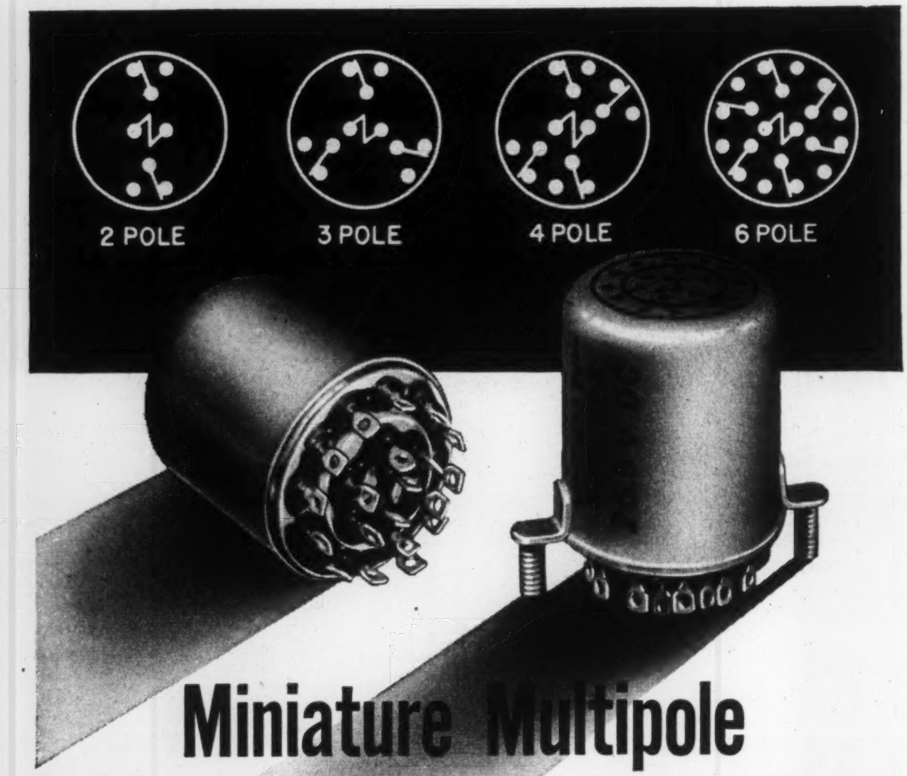
Greater toughness to resist wear years longer was the primary reason that stainless steel got the job. But secondary benefits included greater strength to withstand a press-fit operation, the extra-close I.D. and wall tolerances of Republic ELECTRUNITE Tubing, high resistance to corrosion, and non-magnetic properties.

Somewhere in your product there may be a job that can be done far better by stainless steel . . . or exclusively by stainless steel. We'd welcome the invitation to put Republic's Tubing Specialists to work on that problem. When may we call?

REPUBLIC STEEL CORPORATION
STEEL & TUBES DIVISION
224 EAST 131st STREET • CLEVELAND 8, OHIO

REPUBLIC STEEL ®

Republic
ELECTRUNITE
STAINLESS STEEL TUBING AND PIPE



Miniature Multipole Relays for Jet-Propelled Jobs!

AIRCRAFT OR GUIDED MISSILE

These miniature d-c relays—only $1^1/_4''$ D x $1^9/_{32}''$ H (excluding terminals and mounting studs)—insure faithful performance when subjected to extremely severe operating conditions such as encountered in missiles and aircraft.

Specifically designed to meet the requirements of USAF specification MIL-R-5757, they are supplied for use in 200°C. (type A) and 85°C. (type B) ambient temperatures.

Available in contact combinations of 2, 3, 4 and 6 poles and rated 2 amperes, 26.5 volts D.C. and 115 volts, 400 cycles A.C.

Write for Data Bulletin 2420 for detailed information.

STRUTHERS-DUNN

5,348 RELAY TYPES

STRUTHERS-DUNN, INC., 150 N. 13th ST., PHILADELPHIA 7, PA.

BALTIMORE • BOSTON • BUFFALO • CHARLOTTE • CHICAGO • CINCINNATI
CLEVELAND • DALLAS • DETROIT • KANSAS CITY • LOS ANGELES
MINNEAPOLIS • MONTREAL • NEW ORLEANS • NEW YORK • PITTSBURGH
ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

trial sales engineer in Philadelphia. He will serve the eastern Pennsylvania, New Jersey, Delaware, Maryland and Virginia area.

◆

William R. Sturgis has been transferred to the sales department of Blood Brothers Machine Co. to cover the Southwest territory. Mr. Sturgis has been employed at Blood Brothers since 1940. Also announced was the advancement of **Don F. Wilber,** sales representative for the past six years, to the position of assistant sales manager.

◆

E. F. Houghton & Co. has announced the election of **William F. MacDonald** as president of E. F. Houghton & Co. of Canada Ltd., Toronto, Ontario, Canada, succeeding the late G. W. Pressell, former president. **E. H. MacInnis** continues as vice president and sales manager in the Toronto headquarters, 100 Symes St. The company also announced the appointment of **Carlos H. Mercado** as manager, foreign sales department, succeeding **L. J. Norris,** who has retired because of ill health.

◆

Edward J. Crowe has been appointed sales manager of the powder metal parts division by Keystone Carbon Co., Saint Marys, Pa.

◆

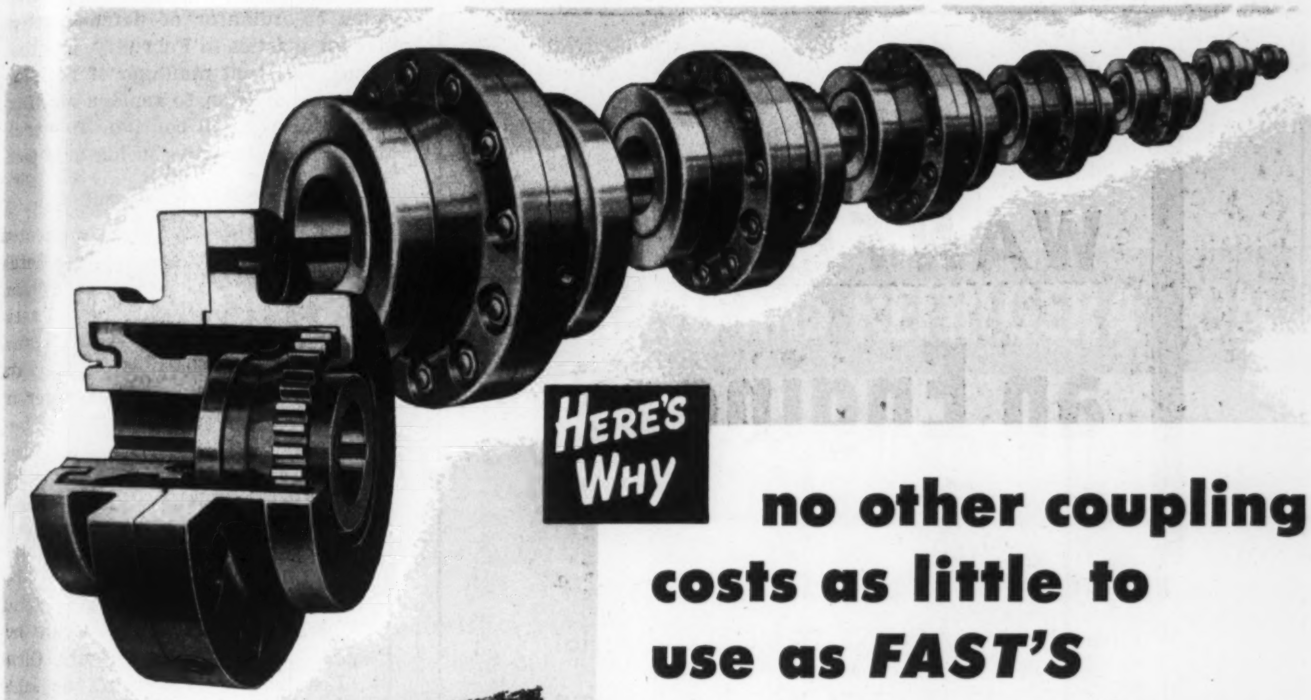
The promotion of **M. A. Moore** to the post of Eastern division manufacturing and sales manager of the Double Seal Ring Co. of Fort Worth, Tex., was announced recently. Mr. Moore, formerly sales and service representative in Maine, Vermont and New Hampshire, has assumed his duties in the company's Eastern division factory and sales office at New Rochelle, N. Y.

◆

Edward Burke has been appointed district representative for The Hansen Manufacturing Co. of Cleveland. The Burke Co., 1246 Bush St., San Francisco, Calif., will be exclusive distributors in northern California for Hansen couplings used in pneumatic and hydraulic service.

◆

Recently announced was the appointment of **William R. Dixon** as assistant general sales manager of The Dow Chemical Co. Assistant manager of the company's plastics sales division since 1941, Mr. Dixon succeeds **Dr. L. S. Roehm,** who has accepted an executive position with the A. E. Staley Manufacturing Co. of Decatur, Ill. **Deane R. Ebey,** who be-



HERE'S WHY

no other coupling costs as little to use as *FAST'S*

With Fast's Couplings you get the lowest coupling cost per year that modern engineering can provide—*because Fast's normally outlast the equipment they connect.* That means their cost can be spread out over 20 years or more!

As two users recently said:

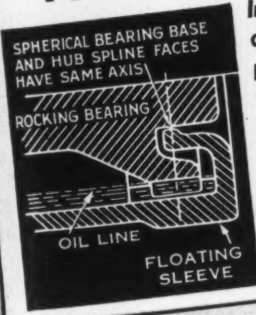
"We've had this Fast's Coupling since 1930 . . . and it's apparently going to last forever. [Wish] the other equipment caused as little trouble!" . . . "We have two Fast's Couplings . . . they are the only equipment so trouble-free we long ago forgot we had them!"

If you want lower costs, freedom from coupling shutdowns and dependable coupling engineering—specify Fast's. For complete details, mail the coupon for Fast's free catalog. Do it today!

RUGGED CONSTRUCTION:

Fast's still maintains its original design, without basic change or sacrifice in size or material. This assures you freedom from needless and expensive coupling failures.

FOOLPROOF DESIGN:



Instead of perishable oil seals, Fast's Couplings use a permanent metal-to-metal closure to keep dust out and oil in. Oil is always maintained at a safe level whether the Fast's is running or standing still.

FREE SERVICE:

When you specify Fast's Couplings you get Koppers' valuable free coupling service. If your application seems to need a special coupling, Koppers' engineers in many cases can easily modify a standard Fast's Coupling, and save you money!

FAST'S
COUPLING

MAIL COUPON TODAY FOR FREE CATALOG!

KOPPERS CO., INC., ***Fast's Coupling Dept.,***
245 Scott St., Baltimore 3, Md.

Gentlemen: Send me Fast's Catalog which gives detailed descriptions, engineering drawings, capacity tables and photographs.

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THE ORIGINAL
GEAR-TYPE

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INDUSTRY'S STANDARD FOR 31 YEARS

WANTED:

an Engineer

We need, on MACHINE DESIGN's editorial staff, a design engineer who has genuine writing interest and ability.

He should have some practical experience in design and be familiar with the method of operation of an engineering organization.

He should be enthusiastic about writing and be able to obtain and organize information from various sources into articles of practical value to engineers.

His work would include traveling in quest of editorial material—visiting plants and attending engineering conventions and expositions.

Somewhere among MACHINE DESIGN's 60,000 readers is the man we want. If you think you are this man, write to the Editor, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio, telling all about yourself.

came co-ordinator of defense activities for plastics in February, has been named assistant manager of the plastics sales division to replace Mr. Dixon. Mr. Ebey will continue to handle the defense activities in his new post.

◆

R. B. Little has been appointed general sales manager of the Eaton Manufacturing Co., Reliance division. He served for five years in the sales department of the Republic Steel Company's New York office. In 1939 he was appointed sales manager in charge of the New York district territory for the Moltrup Steel Products Co. of Beaver Falls, Pa., in which capacity he served until joining Eaton Manufacturing Co. as a sales representative.

◆

Appointment of **W. D. Evan Jr.**, Pacific Industries, 1046 South Olive St., Los Angeles 15, Calif., as sales representative to succeed Robert Young & Co., has been announced by the Marcus Transformer Co., Hillside, N. J.

◆

J. R. Lewis has been appointed assistant general sales manager of Quaker Rubber Corp., Philadelphia, a division of H. K. Porter Co. Inc. He has been with Quaker since 1940, having held positions as Philadelphia district sales manager and assistant sales manager. In his new position, Mr. Lewis will assist the general sales manager in providing better service to distributors and customers.

◆

At a recent board meeting **Theodore E. Spilker,** secretary, was made a vice president and secretary of Nice Ball Bearing Co., Philadelphia. **John E. Mullen,** formerly plant manager, was also made a vice president, and **Henry M. McAdoo,** assistant to Mr. Mullen, was advanced to the position of plant manager.

◆

David L. Matthews has been appointed plant manager of the Avon Lake, O., general chemicals plant of B. F. Goodrich Chemical Co.

◆

The appointment of two experienced Cummins Engine Co. sales executives as direct factory representatives to governmental agencies has been announced. **C. B. Foster** will head a new department of the sales division as manager of contract sales, and **John W. Post** has been named regional manager of the newly created Washington, D. C., region. Company officials indicate that this move

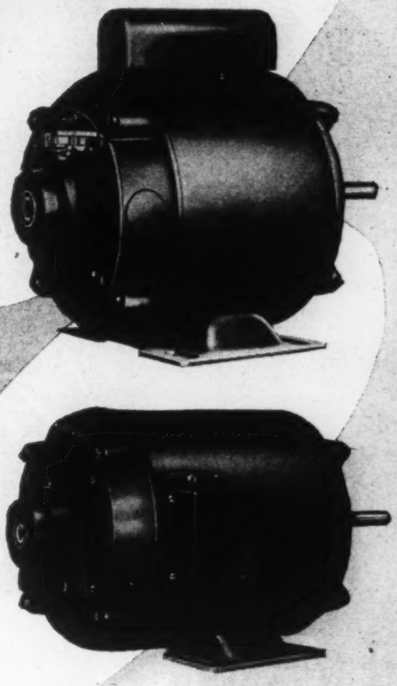
Century MOTORS

FOR HEATING, VENTILATING AND REFRIGERATION

Assure Satisfactory Performance

Because:

- Correct operating characteristics provide top performance for each kind of equipment they drive.
- They start quietly and run quietly.
- Sturdy construction means long life—insulation resists dampness in basements where much of equipment is used.
- An Authorized Century Service Station is near to give fast service when it is required. Get acquainted with your Century Service Station operator.



Typical Century Motor Applications

- **Oil Burner Motors** — meet requirements of underwriters — each motor is balanced — smooth, trim appearance, easy to clean — compact dimensions — all mounting dimensions industry standard.
- **Unit Heater Motors** — NEMA standard for shaft mounted Fans and Blowers. Furnished: single speed — two speed or adjustable speed. For operation on single or polyphase or direct current.
- **Fan or Blower Motors** — For attic fans — window fans—exhausters—air spreaders—furnace blowers. A. C.—D. C. Motors for all forms of air moving jobs.
- **Stoker Motors** — For home and commercial sizes.
- **Refrigeration Compressor Motors**—Up to 400 H. P. —single or multi-speeds — high starting torque for hard-to-start loads — designed for use with automatic starters for refrigeration cycling. Century motors are widely known for their unusually quiet *starting* and *running*.
- **Pump Motors** — Up to 400 H. P. — for water circulating heating systems — refrigeration systems — all form of liquid moving.

Century offers a wide range of types and sizes up to 400 H. P. — with operating characteristics to suit the wide range of driven equipment. Call a Century Branch sales office or your local distributor.

711

Century C MOTORS

CENTURY ELECTRIC COMPANY • 1806 Pine St., St. Louis 3, Missouri

Offices and Stock Points in Principal Cities

Century Electric Company Is Celebrating its 50th Year in the Electrical Industry

Built for Rugged
PERFORMANCE
Protected by
LORD
MOUNTINGS

Compressors must give dependable service under gruelling conditions of rough terrain, mud, and constant exposure to the shock and vibration of drilling. Unless protected from shock and vibration, even the most rugged equipment is subject to excessive down-time and maintenance.

Ingersoll-Rand Company solves this problem in its rugged mobile "Quarrymaster." Each of the 10,000-pound compressor power plants is protected by four LORD Bonded-Rubber Mountings which prevent shock and vibration from interfering with efficient performance. They also prevent excessive twisting stresses in the power plant when the "Quarrymaster" is moving over uneven ground.

Whether your product is large or small, reduction of shock and vibration improves performance and accuracy . . . lowers maintenance costs . . . increases customer satisfaction. Investigate LORD Vibration Control Mountings and Bonded-Rubber Parts. Write to attention of Product and Sales Engineering Department.

LORD MANUFACTURING COMPANY, ERIE, PA.

Canadian Representative: Railway & Power Engineering Corporation, Ltd.

LORD BONDED RUBBER

Vibration-Control Mountings
. . . Bonded-Rubber Parts

will result in closer co-ordination of the factory's activities to the accelerating demand for Cummins diesels by the nation's mobilization program.

◆

Howard K. Suter, formerly identified with the aviation engineering and sales division of Western Gear Works, has been named plant manager of Rosan Inc. of South Gate, Calif. Mr. Suter will be in full charge of Rosan manufacturing facilities and will be responsible for developing new methods and expediting the flow of orders through the plant.

◆

William R. Wilkinson has been appointed vice president for sales, Johns-Manville Corp., and **Kenneth W. Huffine** has been appointed vice president for production.

◆

Associated with the division sales organization for more than 20 years, **Chester W. Schweers** has been named director of sales of the Allis-Chalmers Mfg. Co. general machinery division. **Merton M. York,** since June, 1950, manager of the Boston district office is now manager of the New England region, succeeding Mr. Schweers.

◆

John R. Fennie has been appointed manager of the tubular products department of Joseph T. Ryerson & Son Inc., steel distributors, Los Angeles. In his new position, Mr. Fennie heads the department responsible for merchandising tubular products including seamless and welded mechanical tubing, pressure tubing, hydraulic cylinder and line tubing, and structural tubing.

◆

Leopold Van Bierkom has been appointed assistant general sales manager of Tagliabue Instruments division, Weston Electrical Instrument Corp., Newark, N. J. He has been associated with Tagliabue for 17 years and was sales manager for the company's pyrometer and moisture meter lines prior to his new appointment.

◆

Wallace B. Strathdee and **H. Raymond Benson** have been appointed to top executive positions at the New England district headquarters of the Westinghouse Electric Corp., Boston. Mr. Strathdee was named manager of the marine and industrial departments, and Mr. Benson is the new manager of the transportation department. Both men have served their entire business careers with Westinghouse.

SAVE metal

SAVE man-hours

SAVE money

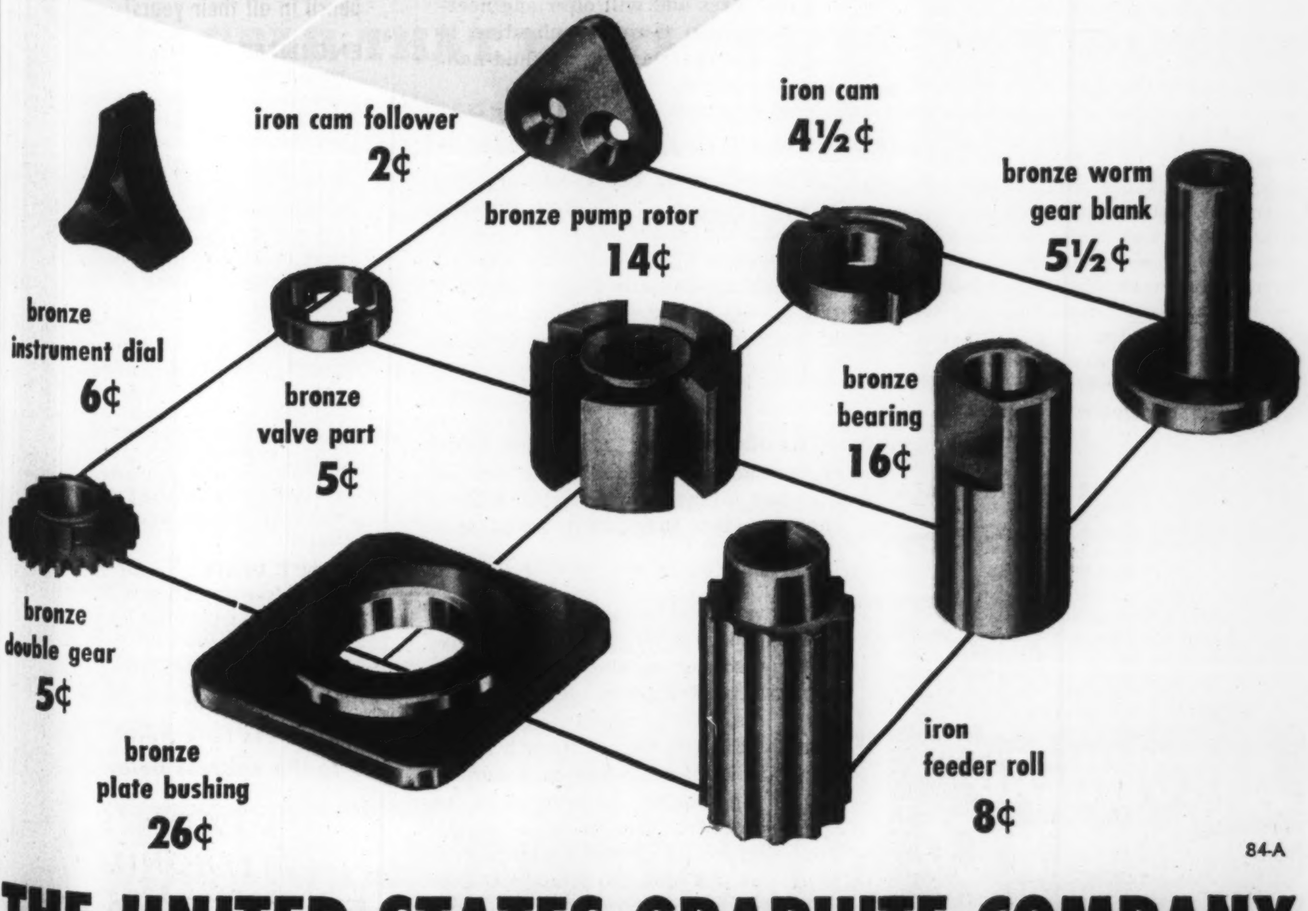
with GRAMIX® parts

By using Gramix parts, die-pressed of powdered metal mixtures, in place of machined parts in products, you can make three important savings—savings that are becoming more vital with every day that passes.

GRAMIX PARTS SAVE METAL. They are made with minimum scrap and waste . . . pound-for-pound more pieces can be produced from Gramix than can be obtained from solid or bar stock that is in tight supply today.

GRAMIX PARTS SAVE MAN-HOURS and machining time because, they are die-pressed to tolerances as close as .0005" . . . the machining time saved can be made available for defense weapon production.

AND, GRAMIX PARTS SAVE MONEY because in quantity lots they can be produced at considerable less cost than identical machined parts. Then too, Gramix parts are oil-impregnated for self-lubrication thus eliminating the need for servicing. Add up the advantages and you'll see why it'll pay you to go to Gramix . . . the leader in the powdered metal field. Write us for the full story.


bronze instrument dial 6¢
iron cam follower 2¢
iron cam 4½¢
bronze pump rotor 14¢
bronze worm gear blank 5½¢
bronze valve part 5¢
bronze bearing 16¢
bronze double gear 5¢
bronze plate bushing 26¢
iron feeder roll 8¢

84-A

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

SILICONE "O" RINGS OFFER UNIQUE DESIGN POSSIBILITIES

LOW TEMPERATURE SYNTHETIC RUBBER
HEAT RESISTANT SYNTHETIC RUBBER
SILICONE RUBBER
Temperature, °F

Because of the inherent stability of silicone rubber, Arrowhead "O" rings molded of this remarkable new material provide a long-lasting seal under conditions far beyond the limits of ordinary rubbers. For example, they remain flexible at -130° F.; withstand indefinitely, exposure to temperatures of 500° F. and over. They offer excellent resistance to oxidation, to many oils, acids, alkalies and a variety of chemicals. The ideally inert characteristic of these seals is demonstrated by their astonishing resistance to aging, even at abnormally high temperatures. At normal temperatures they last *indefinitely*. For superior performance under severe conditions, consider silicone rubber. Arrowhead's *silicone specialists* will welcome your inquiry.

Write FOR ENGINEERING DATA

Free to Engineers—two valuable new publications on silicone rubber and "O" rings. Contain complete technical and descriptive data, including typical applications.

ARROWHEAD RUBBER CO.
Division of
National Motor Bearing Co., Inc.
DOWNEY (Los Angeles County) CALIF.

"O" RINGS ▾ SILICONES ▾ ~~AIRTRON~~ DUCTS

SALES Notes

OPENING of a sales office at 120 East Third St., Charlotte, N. C., has been announced by **Cutler-Hammer Inc.**, Milwaukee electrical manufacturers. The office will be operated as a branch of the company's Atlanta district sales office and will be staffed by Frank A. Miller Jr. and C. Lee Shaw.

◆

A new branch office of the **Allis-Chalmers Mfg. Co.** general machinery division has been opened in Peoria, Ill. Stanley E. Bovim is manager of the office, and F. D. McGuire Jr. has been transferred from the Chicago district office as sales representative.

◆

Shields Rubber Co., 564 West Randolph St., Chicago, has been appointed distributor for O-rings manufactured by **The Parker Appliance Co.**, Cleveland. The company will carry service stocks of O-rings in a wide range of sizes and will offer engineering counsel on O-ring application in sealing hydraulic and other fluid-handling equipment.

◆

With offices at 445 West 23rd St., New York 11, N. Y., **Control Systems Co.** has been established as a dealer in components for electronic control equipment. Initially, the company will handle the standard components of **Servomechanisms Inc.**, Mineola, N. Y.

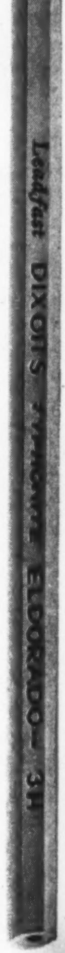
◆

The Kansas City, Mo., sales office of **Synthane Corp.** has been moved to new and larger quarters at 311 Merchandise Mart Bldg., 2201 Grand Ave.

◆

A new education program designed to aid in the rapid training of industrial personnel in the selection and application of modern electric motor drives has been announced by the **General Electric Co.** Fifteenth in the Company's "More Power to America" series, the program is devoted to the task of quickly indoctrinating qualified personnel in the nation's factories as an aid to industrial mobilization. Consisting of nine slidefilms, student review booklets on each lesson, and an instructor's manual, the program was distributed in April to

How that *New-Type* ELDORADO Draws Engineers!



Engineers acclaim the great new-type ELDORADO as the finest drawing pencil in all their years!

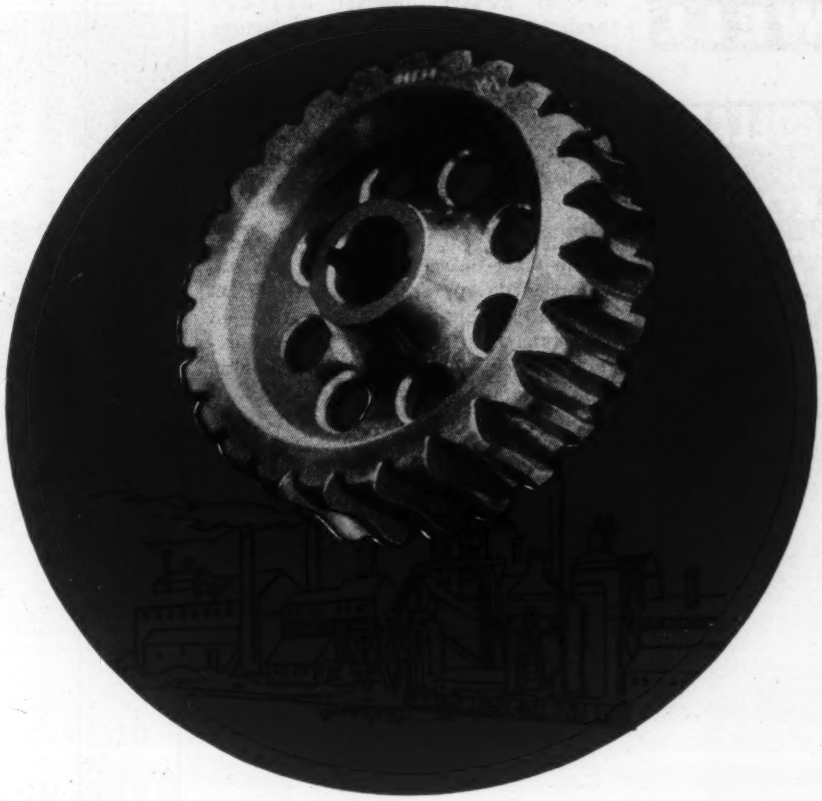
ENGINEER: The Eldorado range of H's are my pencils for they are graded with accuracy. Leads are smooth, lines and numerals clean and opaque... blueprints sharp and clear.

ELDORADO: Correct, that's because you've been using the *new-type* Eldorado! Its lead is stronger ...denser, more uniform. Eldorado means longer point-life. Its *Leadfast* process insures no splintering or burring—its lead is truly-centered. The hexagonal shaft of Eldorado has rounded, smooth edges that put ease in your drawing hand.

DON'T WAIT... send for your free samples of the *new-type* Eldorado today ...the two degrees most useful to you.

Write on your business letterhead to the address below.

DIXON'S TYPHONITE
ELDORADO
Joseph Dixon Crucible Co., Pencil Products
Division 101-J5, Jersey City 3, N. J.



Found:

ONE GEAR THAT LASTS AS LONG AS THREE

Another case that shows how National Bearing Division has reduced operating costs

When any machine makes a habit of breaking down periodically, it's time to take stock of the problem—before production losses and replacement costs skyrocket. That's just what faced a large Midwest steel plant . . . frequent breakdowns of a takeup frame used in coiling wire. The wire, under tension, built up stresses that caused the transmission gears to strip.

National Bearing Division engineers made a special study of this mill's problem. They recommended changing to a bronze alloy known for its ability to retain the anti-frictional qualities of bronze, yet have an unusually high degree of strength.

Result? Not a single gear supplied by National Bearing Division in this alloy has stripped in the last three years! That compares with the former average service of just six months.

Any production man will know that the savings are tremendous, especially over a period of years . . . savings made possible by National Bearing Division metallurgical research on bronze application—*plus the engineering skill to interpret this research in terms of solving an on-the-job problem.*

It's another example showing that we have the facilities, the experience and the *proved* ability to save money for our customers on any problem involving . . .

Non-Ferrous Bearings and Castings—
As-Cast or Machined

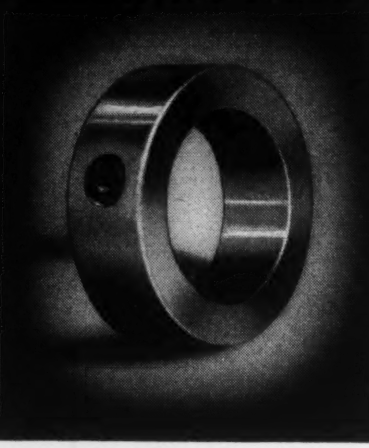
Bronze Bars—
As-Cast or Machined;
Cored, Solid, Hexagon

Babbitt Metals—
For every type of
bearing service

AMERICAN
Brake Shoe
COMPANY

NATIONAL BEARING DIVISION
4931 Manchester Avenue • St. Louis 10, Mo.

PLANTS IN: ST. LOUIS, MO. • MEADVILLE, PA. • NILES, OHIO • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.



HALLOWELL ®

SOLID STEEL COLLARS with UNBRAKO *Self-Locking* HOLLOW SET SCREWS

Used Profitably...

by manufacturers of such widely diversified products as *lawn mowers, food machinery, textile machinery, juke boxes, snow plows, conveyors, air compressors, agricultural machinery, electric fans, bottling machines,* and dozens of others.

Precision machined from solid bar stock in 42 stock sizes for shafts from 3/16" to 3" diameters inclusive.

Write for prices and name of your nearest distributor.

SPS

STANDARD PRESSED STEEL CO.

JENKINTOWN 18, PENNSYLVANIA

General Electric district offices throughout the country for showings to interested groups, including users and potential users of electric motors, application engineers, power sales engineers, machinery manufacturers, designers, contractors, consulting engineers, and students.

◆

The **Taft-Peirce Mfg. Co.** has announced the appointment of the **J. L. Osgood Machinery & Tool Co.,** 43 Pearl St., Buffalo, N. Y., as its exclusive representative for machine tool sales in the Buffalo and Rochester, N. Y., territory.

◆

As a means of helping the supply situation during the present period of scarcities, **All-State Welding Alloys Co. Inc.,** White Plains, N. Y., has announced that all of its distributors are now prepared to arrange for the flux-coating of gas welding rods.

◆

Federated Metals Division, American Smelting and Refining Co., recently completed a new office building at 9000 Market Street Rd., Houston, Tex. Utilized by the company's local administrative personnel, the new building was constructed to handle the increased volume of business realized by Federated in the Gulf Coast area. It was felt by company officials, too, that expanding mobilization efforts and the marketing in the Southwest of several new products would soon create further demands on operations there. Adequate means of handling this activity are now available.

◆

A new branch office of **The Foxboro Co.** has been opened at 618 West Church Ave., Knoxville 16, Tenn. Marvin L. Cleaton Jr., formerly in charge of the company's office at Columbus, O., has been named branch manager.

◆

To serve southern California and Arizona, a complete warehouse and sales office near Los Angeles at 3320 Fruitland Rd., Vernon, Calif., has been opened by **The Bassick Co.,** Bridgeport 2, Conn.

◆

Arcos Corp., welding electrode manufacturer of Philadelphia, recently opened a sales office and warehouse in Chicago. Walter Gordon List, former special field engineer in the Ohio-western Pennsylvania territory, was named district manager.

"The Thinker," first known as "The Poet," was intended to sit at the top gate of hell and contemplate the scene at his feet.

Engineers . . . Designers . . . Superintendents . . .

have earned an exalted place among America's best thinkers. Contemplating each move in advance, their productive genius has astounded the entire world.

These men are sincerely invited to inspect this modern plant where balls only (not bearings) are made.

Here you will see a sound-proof room where *your* bearings are assembled with *Universal Balls* and tested for quiet running and vibration characteristics before shipment.

We make Super Precision balls. The art of making balls within ten millionths of an inch and as small as .025 of an inch is the result of long years of study, scientific research and special manufacturing equipment, most of which has been made in our own plant.

Universal Balls have been used by the largest, most meticulous bearing manufacturers in the U. S. A. and abroad since 1942.

Whenever you need precision balls of extremely fine tolerances, perfect surface finish, sphericity and size accuracy that reduce friction, wear and maintenance costs to an absolute minimum, guaranteed 100% inspected and individually gauged, specify Universal Precision Balls.

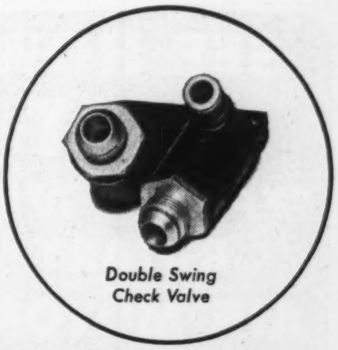
UNIVERSAL BALL CO.

PRECISION BALLS OF CHROME AND STAINLESS STEEL, BRONZE AND SPECIAL METALS.

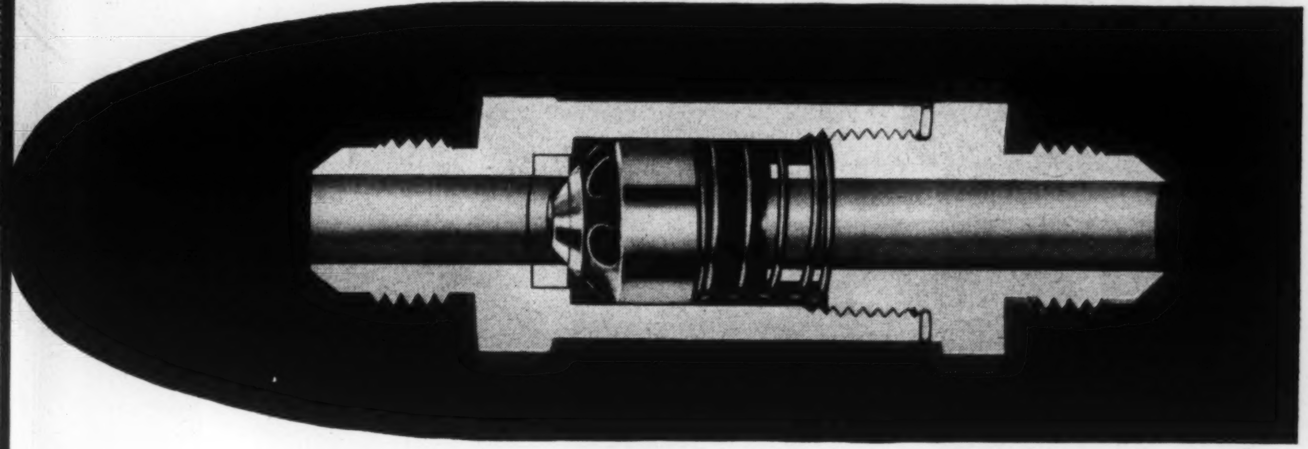
WILLOW GROVE, Montgomery County, Pa.
Telephone, Willow Grove 1200

KOHLER

PRECISION PARTS



Double Swing Check Valve



Cone Type Check Valve

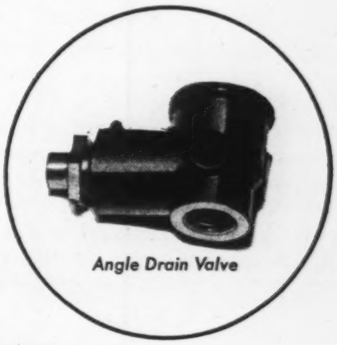
AIRCRAFT • INDUSTRIAL • AUTOMOTIVE

Solenoid Drain Valve

KOHLER PRECISION PARTS are used by manufacturers of Diesel engines, automobiles, trucks, tractors, jet engines, military, commercial and private aircraft, and for agricultural and industrial test equipment.

With an organization experienced and skilled in precision workmanship, Kohler maintains full facilities for forging, casting, machining, anodyzing, assembling, and testing.

Kohler engineers will develop precision valves and fittings for volume production to meet special applications. Write for a catalog and send your specifications or requirements.



Angle Drain Valve

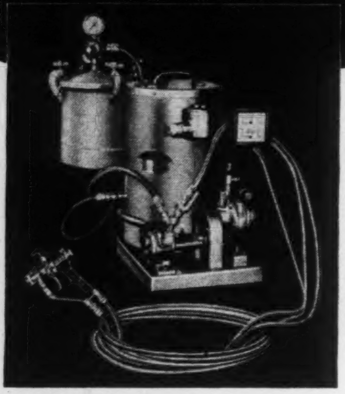
Fuel Dump Valve

KOHLER CO., KOHLER, WISCONSIN. ESTABLISHED 1873

KOHLER OF KOHLER

PLUMBING FIXTURES • HEATING EQUIPMENT

ELECTRIC PLANTS • AIR-COOLED ENGINES • PRECISION PARTS



SEE HOW GAST explosion-proof ROTARY AIR MOTORS helped solve this problem!

PROBLEM: Specify a motor to drive liquid pump at variable speeds, for Bede Circulating Paint Heater. (A unit for faster, more uniform application of hot finish.)

SOLUTION: A Gast Rotary Air Motor, running below 500 r.p.m., drives pump at 150 r.p.m. Uses less than 30 p.s.i. air pressure.

RESULT: Power that's economical, dependable, safe. With explosion-proof Gast Motor, entire unit was approved by Underwriters' Laboratories.

Your problem may be entirely different — yet the *unique advantages* of Gast Rotaries may offer just what your product requires. In sizes from 1/20 to 3 h.p., Gast Air Motors are amazingly compact and light in weight. And overloads can't burn them out!

Write Gast, describing your original equipment application. We'll send full details. "Air may be your Answer!"

Gast Application Ideas Booklet—showing 26 design problems solved — sent upon request.

see our CATALOG in SWEET'S FILE for product designers

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

AIR MOTORS • COMPRESSORS • VACUUM PUMPS
(TO THREE H.P.) (TO 30 LBS.) (TO 28 INCHES)
GAST MANUFACTURING CORP., 107 Hinkley St., Benton Harbor, Mich.

Meetings

AND EXPOSITIONS

May 16-18—

Society for Experimental Stress Analysis. Annual spring meeting to be held at the Wardman Park Hotel, Washington, D. C. Additional information may be obtained from Dr. Edward Wenk Jr., c/o The David Taylor Model Basin, Washington 7, D. C.

May 23-24—

American Society for Quality Control. Fifth annual convention to be held at the Hotel Cleveland, Cleveland, Ohio. Additional information may be obtained from society headquarters, 22 East 40th St., New York 16, N. Y.

May 24-25—

Society of the Plastics Industry. Annual national meeting to be held at the Greenbrier Hotel, White Sulphur Springs, W. Va. W. T. Cruse, 295 Madison Ave., New York 17, N. Y., is executive vice president.

May 28-June 8—

Canadian International Trade Fair to be held at the Exhibition Grounds, Toronto, Canada. Additional information may be obtained from R. G. Pendrith, Publicity Section, Canadian International Trade Fair, Toronto, Canada.

June 3-8—

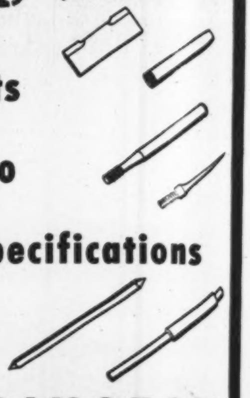
Society of Automotive Engineers. Summer meeting to be held at the French Lick Springs Hotel, French Lick, Ind. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

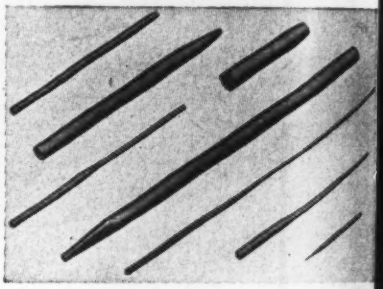
June 4-6—

American Gear Manufacturers Association. Thirty-fifth annual meeting to be held at the Homestead, Hot Springs, Va. Newbold C. Goin, Empire Building, Pittsburgh 22, Pa., is executive secretary.

June 11-16

National Congress of Applied Mechanics to be held at Illinois Institute of Technology, Chicago, Ill., under the sponsorship of the ASME, ASCE, AIChE, AMS, APS, IAS, SESA, U. S. National Committee on Theoretical and Applied Mechanics, Illinois Tech.,





YOU SAVE on parts made to your specifications by TORRINGTON

You save time and money when you rely on our high productive capacity and special equipment to turn out precision parts to your order.

Typical are surgical and dental instruments, pen and pencil barrels, soldering iron cases, etc. Medium wall tubing up to 2½" O.D. and solid steel .015" to ⅝" diameter handled.

We are also set up to make such parts as special rollers, shafts, studs, dowel pins, special needles, instrument shafts and pivots, screw driver and ice pick blades, knurled mandrels and spindles, etc.

Send your prints and specifications today for prompt quotation.

THE TORRINGTON COMPANY
Specialty Department
553 Field Street • Torrington, Conn.

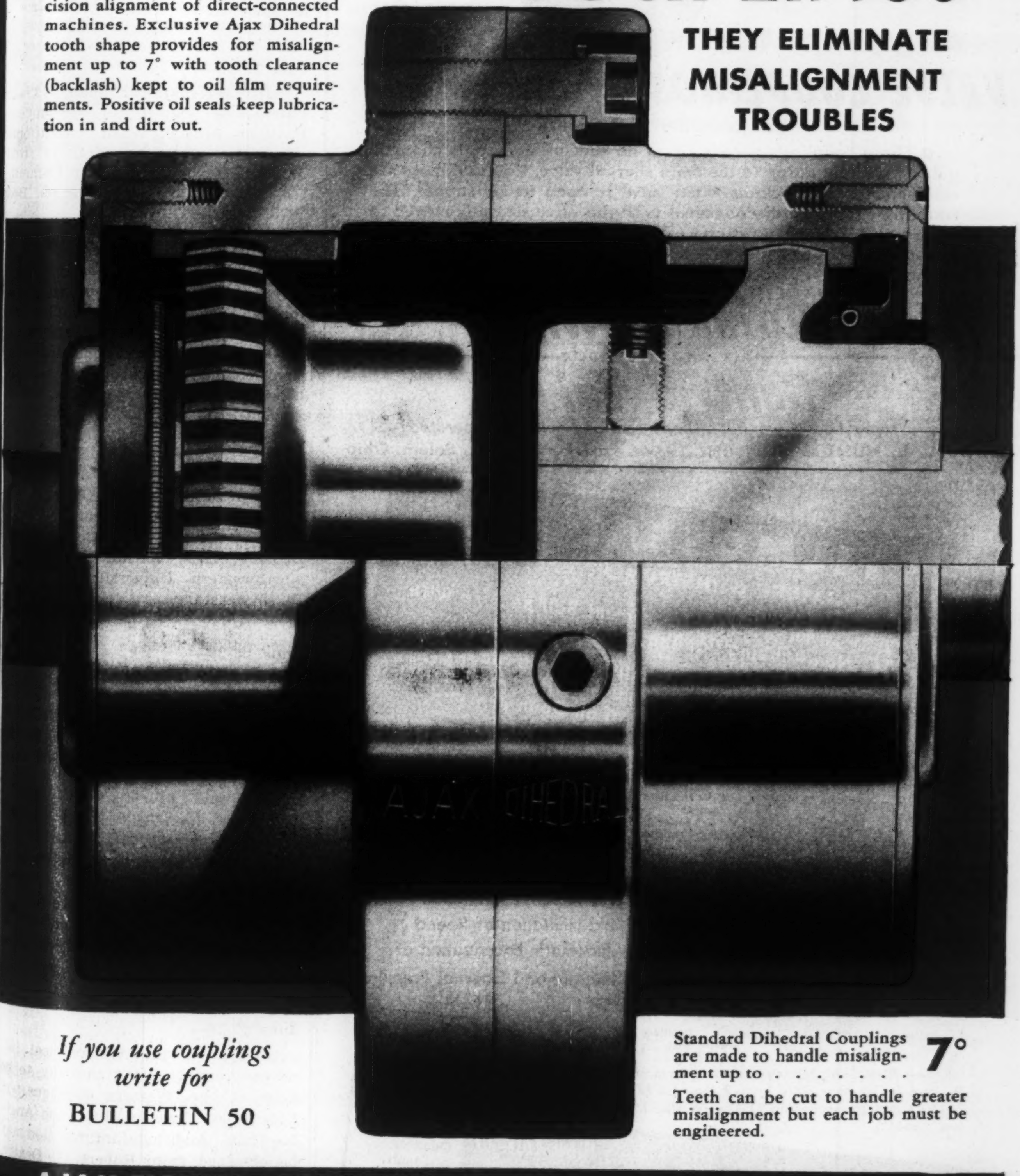
Makers of
TORRINGTON NEEDLE BEARINGS

Announcing AJAX DIHEDRAL COUPLINGS

*

Design, installation and maintenance men can now save thousands of dollars by getting rid of necessity for precision alignment of direct-connected machines. Exclusive Ajax Dihedral tooth shape provides for misalignment up to 7° with tooth clearance (backlash) kept to oil film requirements. Positive oil seals keep lubrication in and dirt out.

THEY ELIMINATE MISALIGNMENT TROUBLES



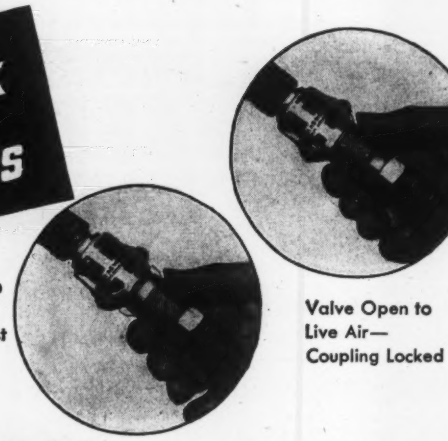
If you use couplings write for
BULLETIN 50

Standard Dihedral Couplings are made to handle misalignment up to . . . . 7°

Teeth can be cut to handle greater misalignment but each job must be engineered.

AJAX FLEXIBLE COUPLING CO. INC. Westfield, New York

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves


Valve Closed to Live Air— Open to Exhaust
Valve Open to Live Air— Coupling Locked

VALVE COUPLINGS 1/4", 3/8", 1/2", & 3/4" SIZES

For Economy and Safety

● These couplings permit air to be shut off and tools changed quickly without going to the main shut-off valve. Coupling jaws are automatically self-locking when valve is open to air supply. The coupling cannot be disconnected until the valve sleeve is moved to closed and exhaust position,— thus preventing accidents and injuries. Pressures to 250 p.s.i.—hose shank, male or female pipe connections. *Send for Bulletin No. 104-C. It gives full details and prices.*

THE HIGHER THE PRESSURE THE TIGHTER THE SEAL

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves

Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

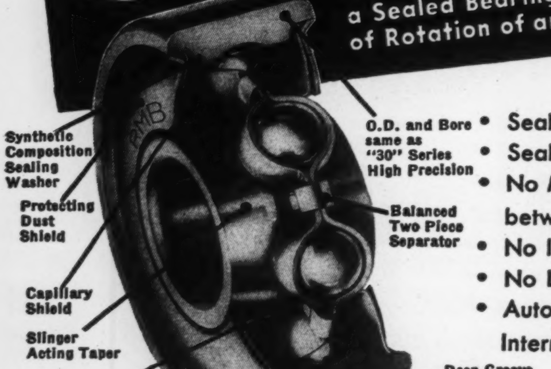
Mfd. by C. B. HUNT & SON, INC., 1946 East Pershing St., Salem, Ohio

NEW FILMOSEAL
MINIATURE & INSTRUMENT BALL BEARING

RMB

The First Sealed Instrument Ball Bearing with Non-Rubbing Capillary Seal!

Combines All the Advantages of a Sealed Bearing with the Freedom of Rotation of an Open Bearing!


RMB
Synthetic Composition Sealing Washer
Protecting Dust Shield
Capillary Shield
Slinger Acting Taper
Capillary Expansion Chamber
O.D. and Bore same as "30" Series High Precision
Balanced Two Piece Separator
Deep Groove Type
Capillary Seal

- Sealed-in OIL Lubrication
- Sealed by a Film of Oil
- No Mechanical Contact between the Sealing Elements
- No Increase in Friction
- No Limitation of Speed
- Automatic Equalization of Internal and External Pressures

The new FILMOSEAL Bearing is made only in precision quality and in 10 bore sizes from 2 mm. (.0787") to 8 mm. (.3150") and corresponding O.D. of 6 mm. (.2362") to 22 mm. (.8661")

Write Today for Complete Descriptive Literature, Price List and Substantial Quantity Discounts.

LANDIS & GYR, INC. 104 Fifth Avenue, New York 11

Purdue University, Northwestern University and University of Illinois. Lloyd H. Donnell, Illinois Institute of Technology, 3300 South Federal St., Chicago 16, Ill., is general chairman.

June 11-15—

American Society of Mechanical Engineers. Semiannual meeting to be held at the Hotel Royal York, Toronto, Ontario, Canada. C. E. Davies, 29 West 39th St., New York 18, N. Y., is secretary.

June 15-30—

Seattle International Japanese Trade Fair to be held in the Edmundson Pavilion, Seattle, Wash. Additional information may be obtained from John M. Haydon, Promotion Committee, c/o Port of Seattle, P. O. Box 1878, Seattle 11, Wash.

June 18-22—

American Society for Testing Materials. Annual meeting to be held at the Chalfonte-Haddon Hall, Atlantic City, N. J. Additional information may be obtained from society headquarters, 1916 Race St., Philadelphia 3, Pa.

June 25-29—

American Society for Engineering Education. Annual meeting to be held at Michigan State College, East Lansing, Mich. Arthur B. Bronwell, Northwestern University, Evanston, Ill. is secretary.

June 25-29—

American Institute of Electrical Engineers. Summer general meeting to be held at the Royal York Hotel, Toronto, Ontario, Canada. H. H. Henline, 33 West 39th St., New York 18, N. Y., is secretary.

June 25-29—

American Society of Mechanical Engineers. Oil and Gas Power Division Conference to be held at the Baker Hotel, Dallas, Texas. C. E. Davies, 29 West 39th St., New York 18, N. Y. is secretary.

June 27-28—

Institute of the Aeronautical Sciences. Annual Spring meeting to be held at the Western Headquarters Bldg., 7660 Beverly Blvd., Los Angeles, Calif. Additional information may be obtained from Robert R. Dexter, secretary, 2 East 64th St., New York 21, N. Y.

New Machines

Heating and Ventilating

REFRIGERATION MACHINES: Reciprocating compressors for air conditioning and refrigeration use. Two models in 100 to 150-hp range. Furnished as complete package units with compressor, cooler, condenser, and all piping, fittings, and controls. Particularly suitable for chilling water for air conditioning purposes. Readily adaptable to industrial applications such as direct product cooling, brine chilling, and ammonia and chlorine condensing. *Carrier Corp., Syracuse, N. Y.*

PRECIPITRON: Encased in 96-in. long air duct. Cleaning capacities ranging from 8330 cfm at 90 per cent efficiency to 44,000 cfm at 85 per cent efficiency. Erected units complete with sealed access doors, flange connections and necessary control equipment. *Westinghouse Electric Corp., Pittsburgh, Pa.*

ROOF VENTILATORS: Power units for schools, hospitals, commercial buildings and industrial plants. In 11 sizes, each size available with 2 to 4 speeds. Housed direct-connected centrifugal fan and motor give positive ventilation independent of wind or weather conditions. Air delivery pressure range, from free air to 1½ in. static pressure. *Ilg Electric Ventilating Co., Chicago, Ill.*

ELECTRIC HEATERS: Wall-mounted home heaters for individual room heating. Built-in thermostat maintains desired temperature in each room. Available in nine ratings from one to 6 kw; all operate on 230/240-v. Heating accomplished by radiation and by circulation of heated air. Each element mounted in separate aluminum deflector. *Westinghouse Electric Corp., Sunnyvale, Calif.*

Heat Treating

BRAZING UNIT: Gas-fired production heating unit for brazing plugs or adapters into ends of shell type units and for annealing mouths of shell cartridges. Machine confines heat to work area; cups which hold pieces rotate on spindles while passing through heating zone. Production rate, 600 pieces per hour on 60-in. diameter unit. Requires

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves

No. 1551-N3
¾ Inch Neutral
Position 3-Way
Air Valve

HAND OPERATED Air Valves

Thousands of Uses Throughout Industry

● Universally used and endorsed. Valving mechanism has stainless steel body and push-pull rods, brass sleeves, self-sealing U-packers and many other refinements, all fully enclosed against dirt, assuring long efficient trouble-free operation. No metal to metal seating. ⅜″ to 1½″ sizes, 3-way and 4-way, neutral position and regular actions. Pipe header mounting plates furnished if desired. *Write for full details.*

THE HIGHER THE PRESSURE THE TIGHTER THE SEAL

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves

Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 1948 East Pershing St., Salem, Ohio

ENVIRONMENTAL TESTING
A VITAL
TESTING SERVICE
FOR
GOVERNMENT SUPPLIERS

The specifications of most Government contracts make it advisable to pre-test components and related equipment before submitting to Government test. We offer Government suppliers testing programs in the following Environmental and Functional Testing Fields, designed to meet official contract specifications:

- VIBRATION (Standard High Frequency)
- SALT SPRAY (Corrosion)
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- HUMIDITY (Varying Condition)
- SAND & DUST
- LOW PRESSURE (Altitude Testing)
- HIGH & LOW TEMPERATURE

Write or call, and we will arrange technical discussions without obligation.

UNITED STATES TESTING COMPANY, INC.
Established 1880
1500 Park Avenue, Hoboken, N. J.
PHILADELPHIA · BOSTON · WOONSOCKET · CHICAGO · NEW YORK · LOS ANGELES · DENVER · MEMPHIS
Member of American Council of Commercial Laboratories

TEAM
AL

TO SAVE TIME ON YOUR PRODUCTION LINES

Allen standards of accurate manufacturing, finish and inspection result in screws and keys that speed assembly and add hours of productivity to every day.

YOU CAN DEPEND ON ALLEN ○ HEAD SCREWS

WARNING Allen-Type screws aren't necessarily Allen-Made. Get genuine "Pressur-Formd" Allen ○ Head screws in this black and silver box.

ALLEN

THE ALLEN MANUFACTURING COMPANY

one operator to load and unload. *Gas Appliance Service Inc., Chicago, Ill.*

Induction Heater Generator: New 5-kw radio-frequency generator for industrial applications where small parts are to be surface hardened, annealed, brazed or soldered. For production line operation where parts are fed through coil, or for small-lot batch operation. Generator features stepless electronic power output control from ½ to 5 kw. *Westinghouse Electric Corp., Pittsburgh, Pa.*

Portable Electric Oven: For preheating plastic granules, treating powdered metals, baking small electronic components, etc. Has four shelves with room for eight 2-in. deep, 12 by 23 in. drying pans. Oven operates from any 110-v outlet, is of steel construction with air-cell asbestos insulation. Forced air circulation provides uniform temperatures. Capable of heating to 225 F in 15 minutes. *Grieve-Hendry Co. Inc., Chicago, Ill.*

Manufacturing

Shell Trimmer: For flat edge trimming of square, rectangular and irregular-shaped drawn shells with small corner radii. Also has capacity for forming, offsetting, beveling, beading, serrating, stenciling, etc. Handles any depth alloy sheet stock up to 13 gage. Equipped with 3-hp, 1750-rpm motor, requires 20 to 80-psi shop air. *Dayton Rogers Manufacturing Co., Minneapolis, Minn.*

Hydraulic Press: Motor-driven 20-ton unit for assembling, broaching, crimping, drawing and forming, and general forcing operations. Double-acting press has 8-in. throat; 12-in. ram travel; 16-in. clearance under retracted ram; ram speed of 60 in. per minute down, 90 in. per minute up. Ram controlled by foot pedal, activated by vane type pump set to operate at 1250 psi. *Ross & Co., Chicago, Ill.*

Band Saw: Light-duty 16-in. throat DoAll machine featuring automatic power feed. Operator is relieved of pushing workpiece into saw band. Feed pressure adjustable, while machine is running, by turning handwheel. *DoAll Co., Des Plaines, Ill.*

Motorized Torch Holder: For remote control raising and lowering of cutting torches mounted on oxyacetylene cutting machines. Designed for mounting on 3 in. sq torch bar, raises or lowers torches 5 in. Remote control switchbox at control

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station actuates each of four torches individually or all four simultaneously. *Air Reduction Sales Co., New York, N. Y.*

GRINDER: For sharpening pipe cutoff blades and thread chasers. Left side of machine designed to sharpen chasers for threading up to 8-in. pipe. Pipe and tube cutoff blades sharpened on right-hand side of machine. Powered by 1½-hp, totally-enclosed, 220/440-v, 3-phase motor. Equipped with manually-operated starting switch, 12-gal capacity coolant system. *Continental Machine Co., Chicago, Ill.*

SPRING GRINDER: Double, vertical-spindle disk grinder with semiautomatic cycling, for grinding coil springs. Grinds springs from ½ to 6 in. long, ¼ to 4-in. diameter, and from 0.0625 to 0.500-in. wire diameter. Springs pass across center of 30-in. diameter abrasive wheels which have no center holes. Disks require average adjustment of only 0.008-in. to compensate for wheel wear for each hour of operation. Feedwheel speed variable from 1/6 to 19 rpm. *Charles H. Besly and Co., Machine Tool Div., Beloit, Wis.*

HAND GRINDER: For industrial plants, pattern shops, foundries, die shops, etc. Operates at 20,000 rpm, with dynamic and static balancing assuring vibrationless performance. With ¼-in. capacity Jacobs universal chuck permitting use of 2-in. grinding wheels or any ⅛ to ¼-in. shank mounted wheels. Length, 11 in.; weight, 5 lb 10 oz. *Chicago Wheel & Mfg. Co., Chicago, Ill.*

BULB-BLOWING MACHINE: For automatic production of up to 2400 bulbs per hour. Incorporates motor-operated knives for more positive and faster cutoff, new improved chucks to reduce waste of tubing ends. Automatic except for hand feeding of 4-ft lengths of glass tubing. Bulbs can be blown to 2½-in. OD by 5½-in. overall length. *Kahle Engineering Co., North Bergen, N. J.*

TAPPING MACHINE: Fully automatic except for loading and unloading. Uses air-operated shuttle type fixture and chucks. Will cut 1$\frac{25}{32}$-16 buttress thread on 4140 seamless steel tubing at rate of 100 parts per hour using 34 ft per minute cutting speed. *The Cleveland Tapping Machine Co., Canton, O.*

SCREW MACHINE: Single-purpose, automatic screw machine specifically for high-speed production of small, precision screws for watch and instrument work. Tornos Automatic Type TV machine uses radial tools for turning and forming or cutting-

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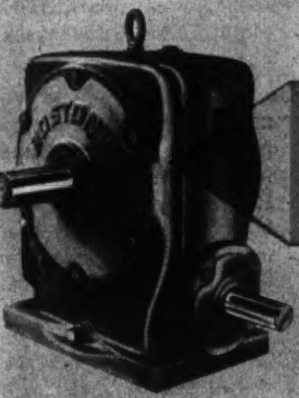

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Take the Case of the Production Welding Machine

A large unit was designed around a low priced speed reducer that gave out in a few weeks and had to be replaced by a BOSTON Reductor. Here is the cost picture:

Net difference in first cost	+ $ 10.50
Cost of repairing machine and replacing gear unit (2 men, 5 hrs. @ $3.00 per hr.)	— 30.00
Loss of production (5 hrs., 12 parts per hr. @ $24.00 per part)	— 1,440.00
NET LOSS	$1,459.50

Take the Case of the Baking Oven

A cut price motorized speed reducer failed and was replaced by a BOSTON Ratiomotor.

Net difference in cost	+ $ 10.40
Cost of overhauling oven and installing new unit (3 men, 4 hrs. @ $2.00 per hr.)	— 24.00
An entire batch of pastry worth $20.00 was lost due to drive breakdown. This, plus production loss (4 hrs., 12 batches per hour @ $20.00 per batch) made a total loss of	— 980.00
NET LOSS	$993.60

The *hidden quality* in BOSTON Reductors and Ratiomotors is very real, even if you don't detect it at first glance. It is the result of BOSTON *Gear's* strict materials control, master craftsmanship and rigid inspection system. This *hidden quality* plus the unequalled convenience and service obtainable from Authorized Boston Gear Distributors (*see adjacent list*) makes it true and lasting economy to:

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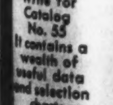

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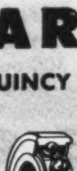

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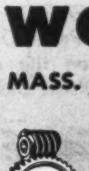

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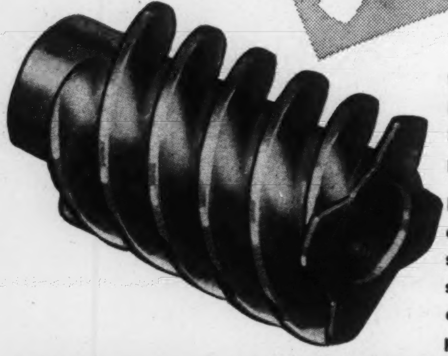

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off operations, employs sensitiv threading spindle and slotting a tachment. Stock capacity, $\frac{1}{32}$-i diameter; max length, 1 in.; ma headstock speed, 12,000 rpm; ma speed of camshaft, 120 pieces p minute. *Carl Hirschmann Co., Ma hasset, N. Y.*

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SEGMENTAL NOTCHING PRESS: Fo notching motor segment lamina tions of larger sizes that cannot b handled in conventional index rin type fixtures. Capacity, from 24-i diameter segments up to straigh line. *V & O Press Co., Div. o Hartford-Empire Co., Hudson, N.*

LATHE ATTACHMENT: Vertical rota attachment for lathes for jig bo ing, drilling, reaming, flycutter fa ing, etc. Angular location of wor accurate to $^1/_{10}$-degree. Fits mo 9 and 10-in. lathes. *Allan Man facturing Co., Long Island Cit N. Y.*

MICRO DRILL PRESS: For accura drilling of holes down to 0.002-i Uses collets in stock sizes from 0. mm (0.004-in.) to 1.0 mm in incre ments of 0.05-mm, and from 1.1 m to 5.0 mm (0.197-in.) in increment of 0.1-mm. Powered by 1/20-h motor with standard pulley spind speeds of 1000, 1750 and 3000 rpm Max drill size recommended, ⅛-i Work fed to drill by raising tabl Max table travel, 1½ in.; max di tance between table and end of spi dle, 4 in. *Louis Levin & Son Inc Los Angeles, Calif.*

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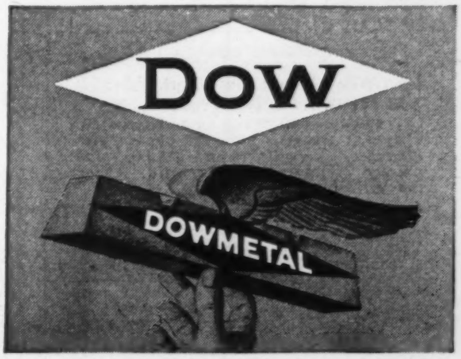

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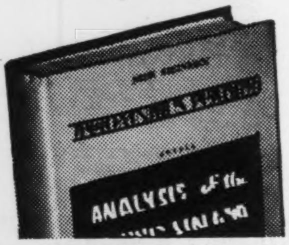

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gun adds metal to metal by fine atomization of wire stock at 6300 F. Unit weighs 20 lb, is designed primarily for stationary operation. Powered by 1/20-hp constant-speed induction motor. Gun sprays #15 B.&S. gage wire up to $\frac{3}{16}$-in. diameter. Speed, from 18 lb per hour for aluminum and nickel to 80 lb per hour for zinc. Variable speed indicator regulated according to metal being sprayed. *Metallizing Co. of America, Chicago, Ill.*

FLASH-BUTT WELDER: Simultaneously welds both ends of tubular chair rung to tubular legs of metal chairs. Because tubes are butt welded, no extra material is required as in brazing. BMFU-75 welder is pneumatically-operated electrical resistance type machine rated at 75 kva, wired for 220 or 440-v, single-phase, 60-cycle power supply. Flashing and unsetting automatically accomplished by air cylinder actuated gear and rack mechanism. Requires 10 seconds per chair, including loading and unloading time, giving production rate of 300 chairs per hour. *Sciaky Bros. Inc., Chicago, Ill.*

STAKING MACHINE: Air operated machine for staking or riveting fixed or movable joints and for eyeletting, inserting grommets, burring, and pointing with platinum, tungsten or silver. Furnished with air foot switch, with dual hand controls available. Spindle uses pressure pad to compress assembly before staking. Hammer blow adjustable. Capacity, 1000 pieces per hour. *The High Speed Hammer Co. Inc., Rochester, N. Y.*

CUTTING MACHINE: Rotary-oscillating hydraulic wet abrasive cutting machine. Work revolves and abrasive wheel oscillates. Cuts round solid bars to 8-in. diameter, tubing to 8-in. OD, ferrous, nonferrous or plastic materials. Temperature of work controlled by proper distribution of coolant. Employs hydraulic wheel feed and work clamps. *Campbell Machine Div., American Chain & Hoist Co. Inc., Bridgeport, Conn.*

TRANSFORMER ARC WELDERS: Indoor or all-weather models in 300, 400 and 500 amp sizes. First two models have automatic "hot starting" control with arc-stabilizing capacitors. Silicone insulation provides safety at high temperatures and is water repellent. No rotating parts except fan on larger two models. *Air Reduction Sales Co., New York, N. Y.*

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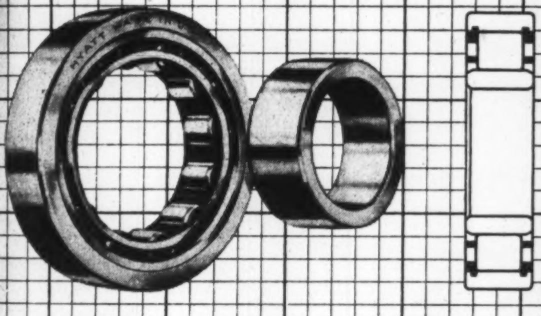

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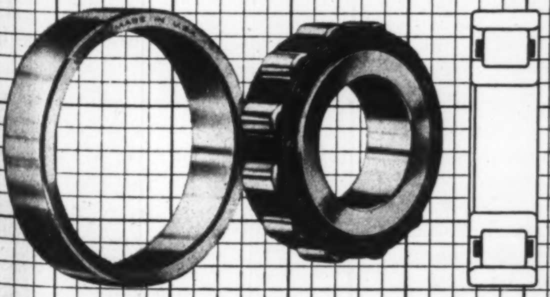

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THE straight cylindrical race in each of the bearings pictured here permits axial freedom of the shaft to accommodate thermal expansion or other limited shaft movement. This is but one of the advantages enjoyed by designers who employ the Hyatt line of Hy-Load Roller Bearings. Others include: option of omitted race operation, complete interchangeability of parts, maximum capacity for standard dimensions—and long trouble-free life.

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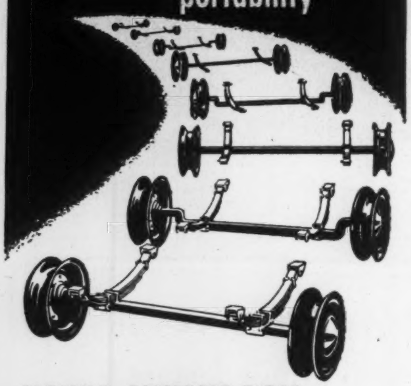

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FORK LIFT TRUCKS: Feature shorter length and width, narrower turning radius than previous models. Available in 15 and 24-in. load centers. Powered by 4-cylinder, 61-cu in. displacement engine in standard mast lift heights of 72, 84, 108, 114 and 120 in. *The Buda Co., Harvey, Ill.*

FREIGHT TRUCK: Battery-operated freight truck for use in plants as pick-up or delivery truck. Load-Mobile permits operator to sit facing either direction, or to stand while driving. In 3000 and 5000-lb capacity models. No-load speeds, 3.5 to 4 mph; full-load speed, 3 and 2.5 mph, respectively. *Market Forge Co., Everett, Mass.*

Packaging

AMPULE PRINTER: For automatic high-speed printing on ampules, vials, carpuls, glass rods, glass droppers, etc. Includes automatic one-color silk-screen printing unit and small conveyor furnace with 1100 F. max temperature to fuse enamel to glass surface. Requires only one operator, produces 3000 to 5000 ampules per hour. Machine adjustable between 25 and 150-mm ampul length. *Ceragraphic Inc., Newark, N. J.*

Plant Equipment

MASONRY SAW: Portable saw in wet and dry cutting types. Uses abrasive or diamond type cutting wheels. Handcrank controls position of self-locking wheel-positioning mechanism. Proper grinding wheel pressure maintained regardless of pressure on foot pedal that controls feeding of cutting wheel into work. Cutting table rides on enclosed ball bearings. *The Supreme Equipment Corp., Cleveland, O.*

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MICROHARDNESS TESTER: Kentron tester for making Knoop or Vickers hardness tests on metals, fine wire, small precision parts, plastics, glass, paint, ceramics, etc. Testing load range increased—instrument applies dead weight loads from 1 to 10,000 grams. Mechanical stage designed to slide specimens

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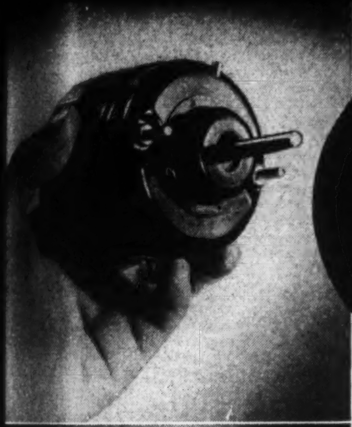

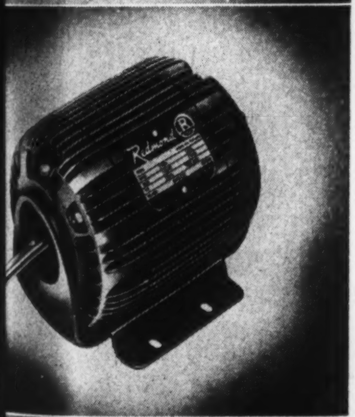

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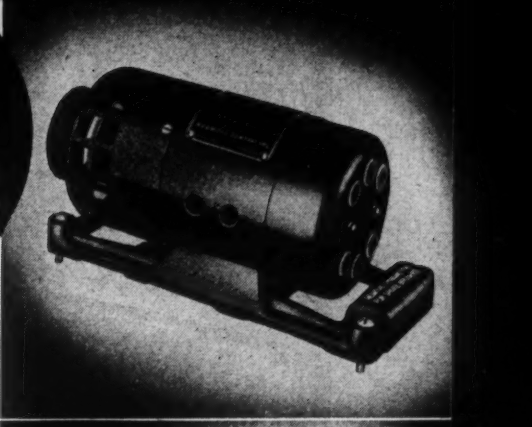

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PORTABLE HARDNESS TESTER: Hardened steel rod locks in cocked position until released by trigger. Plunger rebounds from surface of material being tested, is locked at highest point of rebound. Permits hardness readings on Rockwell C, Rockwell B and Brinell scales. *Peabody Industries Inc., Highland Park, Mich.*

CABIN LEAKAGE TESTER: Portable tester for fighter type aircraft. Measures 24 by 24 by 12 in., weighs 100 lb. Capacity, to 200 cfm free air. For pressure testing from 2.5 to 10 psi; designed to use plant air. *Sprague Engineering & Sales, Gardena, Calif.*

BATTERY TESTING MACHINE: For shaking or "vibrate to destruction" tests. To determine operating characteristics, wear life, etc., of batteries. Vibrations produced by two pairs of rotating unbalanced flywheels operating at 1800 to 2000 rpm. Amplitude is adjustable. Machine powered by 1-hp motor through belt drive. *Deister Machine Co., Fort Wayne, Ind.*

Woodworking Equipment

DISK SANDERS: Two models for use in auto repair and body shops, welding shops, metal fabricating plants, foundries, woodworking plants, etc. Model 460 is heavy-duty sander with 7-in. backing pad, 18-in. overall length, 14-lb weight. Model 465 is standard-duty model, with 9-in. backing pad, 18-in. length without pad, 14¾-lb weight. Powered by ¾-hp universal 220-v motor with 4200-rpm no-load speed. *Cummins Portable Tools, division of Cummins-Chicago Corp., Chicago, Ill.*

POWER HAND SANDER: Model 105 finishing sander for carpenters, auto body workers, home use, etc. Abrasive pad revolves in $\frac{3}{16}$-in. diameter orbit at 5000 rpm. Dimensions, 9 by 3 by 3¾-in. Weight, 5 lb. Uses ⅓ of standard 9 by 11 in. abrasive sheet. *Porter-Cable Machine Co., Syracuse, N. Y.*

RADIAL SAW: Model 450 saw for bevel, miter, rip, dado, plough and rabbet cuts. With either manual or magnetic controls, in various voltage, horsepower and motor cycle specifications. With 14 or 16-in. blades. Requires 4½ by 6-ft floor space, weighs 475 lb. Work table is 11¼ in. deep, can be increased to 13¼ in. if desired. *Skilsaw Inc., Chicago, Ill.*

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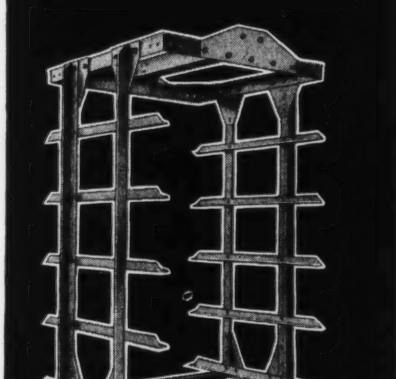

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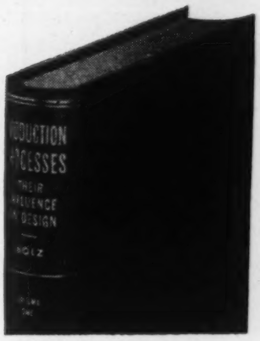

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